BBC

SEE A GEMINID SHOOTING STAR THIS MONTH

THE UK'S BIGGEST SELLING ASTRONOMY MAGAZINE

Sky at Night

#151 DECEMBER 2017

2017: A STELLAR YEAR IN SPACE

- The gravitational wave revolution
- Telescopes that span continents
- Cassini's plunge into Saturn
- And much more...

Christmas GIFTS

Astronomy present ideas to suit every pocket

Seeing stars collide

"I was the first person to 'see' a gravitational wave"

EXTRA ONLINE

VIDEO INTERVIEW

Isaac Newton Telescope manager on 50 years of observations

MAKING WAVES

We speak to the UK-based astronomers hunting for ripples in space-time

INTERACTIVE PLANETARIUM

Our audio-visual guide to December's night sky highlights

CELESTRON®

TECHNOLOGICALLYSUPERIOR

THE NEXSTAR EVOLUTION KEEPS **EVOLVING**

NexStar® **EVOLUTION**

8" EdgeHD with StarSense

Now paired together, enjoy the EdgeHD 8" optics and StarSense AutoAlign on the Evolution Mount. All controlled from your favourite iOS or Android phone or tablet with the new SkyPortal App.

Upgrade your NexStar Evolution for longer exposure astrophotography with the new Evolution equatorial wedge.

NexStar Evolution 8" EdgeHD with StarSense AutoAlign

iPAD and iPHONE SHOWN NOT INCLUDED.

NexStar Evolution 6" SCT

NexStar Evolution 9" SCT

Equatorial Wedge

Sky at Night MAGAZINE REVIEWED IN ISSUE 112 SEPTEMBER 2014 ★★★★★

Available from specialist astronomy retailers and selected other dealers nationwide.

Celestron is distributed in the UK & Ireland by David Hinds Limited. Trade enquiries welcomed.

www.celestron.uk.com

This month's contributors include...

Stuart McIntyre
Astrophotographer

IAPY 2016 shortlisted entrant Stuart reveals how to blend land and sky in his stunning image of the Milky Way. *Page 84*

Elizabeth Pearson
News editor

Elizabeth presents our wrap-up of 2017, featuring Cassini's end, China's ambitions and SpaceX's successes. *Page 33*

Niamh Shaw
Science communicator

What's it like living in microgravity on the ISS? Niamh reviews Tim Peake's new book *Ask An Astronaut* to find out. *Page 102*

Nick Spall
Science writer

Nick reflects on the remarkable Arthur C Clarke, the sci-fi author and futurist whose predictions often came true. *Page 44*

Welcome

2017 has been another incredible year for space science

We've been looking back over the past 12 months. It's been quite a year for space and astronomy: a total solar eclipse traversed the continental US, China pressed on with its plans for a space station, SpaceX announced a bigger rocket to get to Mars by 2024, and astronomers matched gravitational wave readings to an observable event for the first time ever. Elizabeth Pearson looks at more of the biggest stories to have happened this year on page 33.

Looking further back, on page 67 we celebrate the 50th anniversary of UK's Isaac Newton Telescope. It had its first, first light at Herstmonceux, East Sussex, back in 1967 and is one of the few telescopes to have had a second. Also, on page 44 we mark the 100th birthday of sci-fi author and futurist Sir Arthur C Clarke.

And speaking of the future, if you'd like to help shape the content of this magazine in the years to come, follow the link to our reader survey and complete it online. We'd love to hear what we're doing well and what could be better.

Season's greetings and enjoy the issue!

Chris Bramley Editor

PS Our next issue goes on sale 21 December.

Become an Insider

The more we know about what you like, the better placed we are to bring you the best magazine possible. So we'd like to invite you to join our online reader panel 'Insiders'.

Just log on to **www.immediateinsiders.com/register** to fill out the short registration survey and we'll be in touch from time to time to ask for your opinions on the magazine and other relevant issues.

How to contact us

Subscriptions, binders and back issues
03330 162119
Mon to Fri 8am to 8pm; Sat 9am to 1pm for orders
Calls from landlines will cost up to 9p per minute. Call charges from mobile phones will cost between 3p and 55p per minute but are included in free call packages.

Editorial enquiries
0117 314 7411
9.30am to 5.30pm, Mon to Fri

Advertising enquiries
0117 300 8276

Print subscription enquiries
bbcskyatnight@buysubscriptions.com

Digital subscription enquiries
bbcskyatnightdigital@buysubscriptions.com

Editorial enquiries
contactus@skyatnightmagazine.com

Subscription enquiries
UK enquiries: FREEPOST IMMEDIATE MEDIA (please write in capitals)
Overseas enquiries: PO Box 3320, 3 Queensbridge, Northampton, NN4 7BF, UK

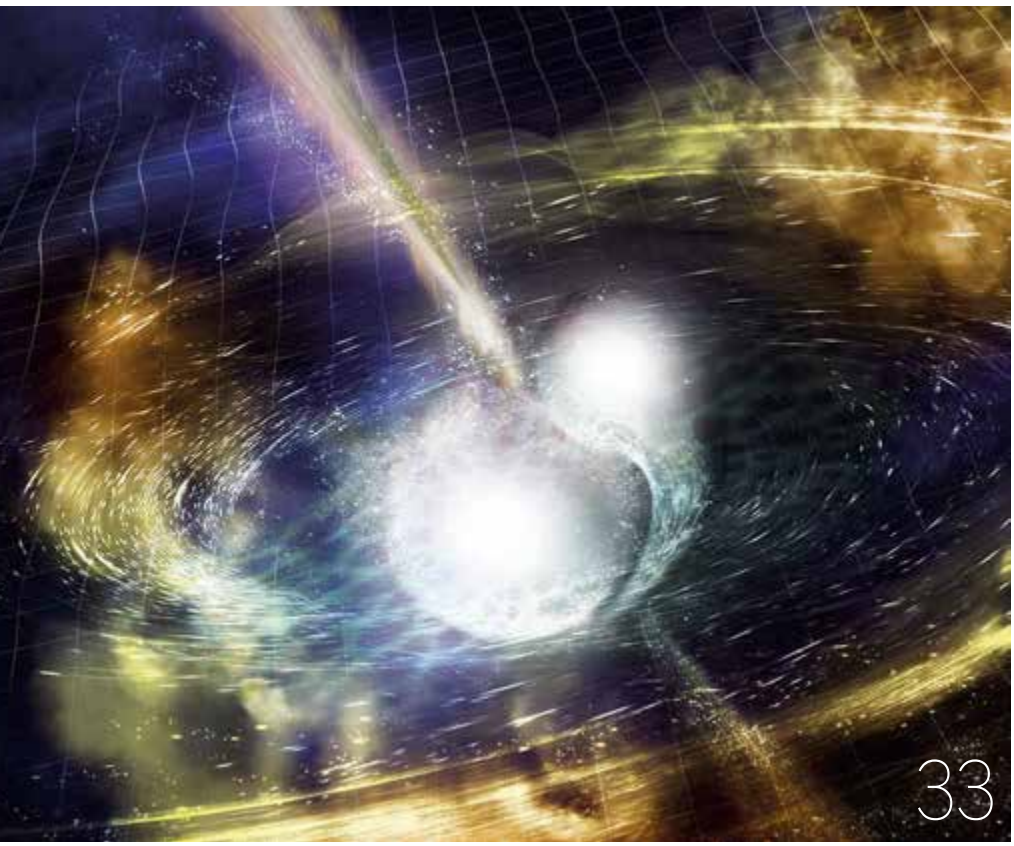
Editorial enquiries
BBC Sky at Night Magazine, Immediate Media Co Bristol Ltd, Tower House, Fairfax Street, Bristol, BS1 3BN

CONTENTS

C = on the cover

NEW TO ASTRONOMY?
Get started with The Guide on page 80 and our online glossary at www.skyatnightmagazine.com/dictionary

Features



Regulars

DECEMBER'S BONUS CONTENT

ACCESS THE CONTENT ONLINE AT
www.skyatnightmagazine.com/bonuscontent
ACCESS CODE: WRXNQ56

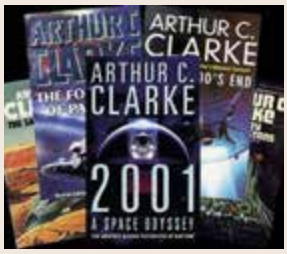
December highlights

The Sky at Night

October's *The Sky at Night* is all about our closest cosmic companion: the Moon. Maggie takes a look at a rover and lander that could be making their way to the lunar surface very soon, while Chris finds out how samples brought back by the Apollo missions are changing our views of how the Moon formed, and whether we could permanently settle there.

Interview: The Isaac Newton Telescope

On its 50th anniversary, INT manager Cecilia Fariña reveals how this UK scope is still going strong.



An introduction to Arthur C Clarke

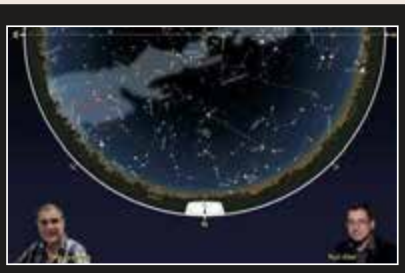
Mark the centenary of the sci-fi author's birth with audiobook chapters from five of his best novels.

Interview: GB and gravitational waves

Two Cardiff University scientists reveal how Britain is involved in the hunt for ripples in space-time.

and much more...

- ▷ **Hotshots gallery**
- ▷ **Eye on the sky**
- ▷ **Extra EQMOD files**
- ▷ **Binocular tour**
- ▷ **Equipment review guide**
- ▷ **Desktop wallpaper**
- ▷ **Observing forms**
- ▷ **Deep-sky tour chart**



EVERY MONTH
Virtual Planetarium
With Paul Abel and Pete Lawrence
Explore December's night-sky highlights with Paul and Pete.

Sky at Night MAGAZINE IMMEDIATE MEDIA Co

***BBC Sky at Night Magazine* is published by Immediate Media Company Bristol Limited under licence from BBC Worldwide, who help fund new BBC programmes.**

EDITORIAL
Editor Chris Bramley
Art Editor Steve Marsh
Production Editor Kev Lochun
News Editor Elizabeth Pearson
Editorial Assistant Iain Todd
Reviews Editor Paul Money

CONTRIBUTORS
Paul Abel, Maggie Aderin-Pocock, Paul Cockburn, Adam Crute, Jon Culshaw, Lewis Dartnell, Glenn Dawes, Mark Garlick, Will Gater, Pippa Goldschmidt, Peter Jenkins, Pete Lawrence, Chris Lintott, Stuart McIntyre, Chris North, Mark Parrish, Steve Richards, Steve Sayers, Niamh Shaw, Benjamin Skuse, Nick Spall, Paul Sutherland, Stephen Tonkin, Paul Wootton

ADVERTISING SALES
Advertising Managers
Neil Lloyd (0117 300 8276), Tony Robinson (0117 314 8811)
Inserts Laurence Robertson (00 353 87 690 2208)

PRODUCTION
Production Director Sarah Powell
Production Coordinator Emily Mounter
Ad Services Manager Paul Thornton
Ad Co-ordinator Emily Thorne
Ad Designers Cee Pike, Andrew Hobson
Reprographics Tony Hunt, Chris Sutch

LICENSING
Director of Licensing and Syndication Tim Hudson
International Partners' Manager Anna Brown

MARKETING
Head of Circulation Rob Brock
Head of Marketing Jacky Perales-Morris
Marketing Executive Craig Ramsay
Head of Press and PR Ridhi Radia

PUBLISHING
Publisher Jemima Ransome
Managing Director Andy Marshall

MANAGEMENT
CEO Tom Bureau

BBC WORLDWIDE, UK PUBLISHING
Director of Editorial Governance Nicholas Brett
Director of Consumer Products and Publishing Andrew Moultrie
Head of UK Publishing Chris Kerwin
Publisher Mandy Thwaites
UK Publishing Coordinator Eva Abramik

UK.Publishing@bbc.com
www.bbcworldwide.com/uk--anz/ukpublishing.aspx

EDITORIAL REVIEW BOARD
Andrew Cohen, Head, BBC Science Unit; **Deborah Cohen**, Editor, BBC Science Radio; **Tim Usborne**, Series Producer, *The Sky at Night*; **Robin McKie**; **Carmen Pryce**

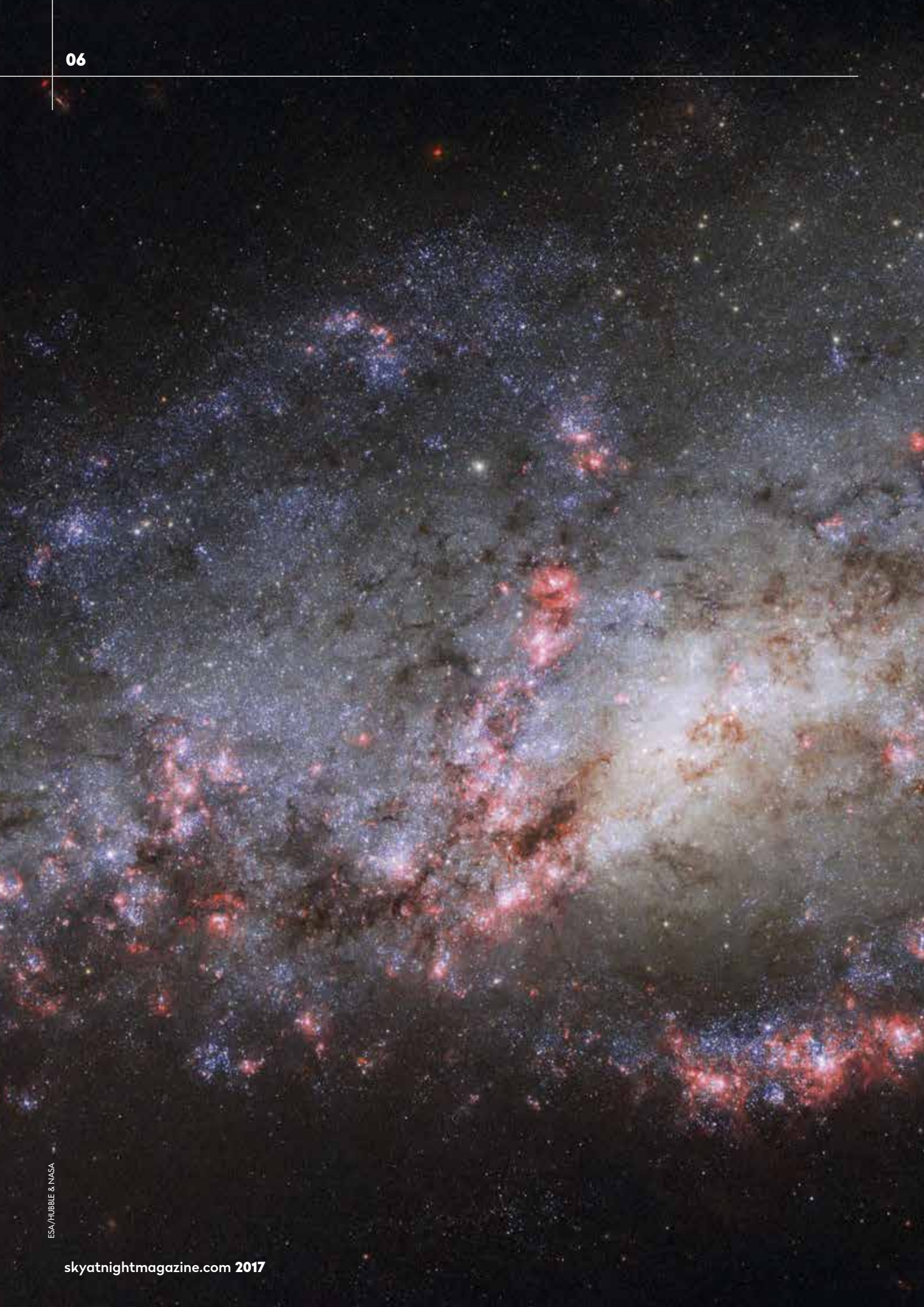
SUBSCRIPTION RATES
Annual subscription rates (inc. P&P): UK cheque/credit card £62.40; Europe & Eire Airmail £75; rest of world airmail £85. To order, call 0844 844 0260

We abide by IPSO's rules and regulations. To give feedback about our magazines, please visit immediate.co.uk, email **editorialcomplaints@immediate.co.uk** or write to The Editor, *BBC Sky at Night Magazine*, Immediate Media Co., Tower House, Fairfax Street, Bristol, BS1 3BN.

abc Audit Bureau of Circulations
23,453 (combined; Jan-Dec 2016)

ISSN 1745-9869

COVER MAIN IMAGE: ESO/N. BARTMANN/SPACEENGINE.ORG, NASA/JPL-CALTECH X 2, SPACE X, ROCKET: PAUL WOOTTON, ESO/B. TAFRESHI (TWANIGHT.ORG), THINKSTOCK, THIS PAGE: WILL GATER, PETE LAWRENCE, NASA/JPL-CALTECH, NSF/LIGO/SONOMA STATE UNIVERSITY/A. SIMONNET, BBC



ESA/HUBBLE & NASA

When galaxies collide

In the life of a galaxy, collisions don't always mean destruction; they can often result in the chaotic birth of something new and beautiful

HUBBLE SPACE TELESCOPE, 28 SEPTEMBER 2017

This active, glowing object is NGC 4490, a galaxy that is still recovering from a collision with a smaller galactic neighbour. It was once a barred spiral, probably similar to the Milky Way, but its shape has been deformed due to its encounter with irregular galaxy NGC 4485, not seen here.

In this Hubble image, the most intense, destructive period of the collision is already over; the two galaxies have passed through each other and are speeding apart once more. NGC 4490, having lost its former spiral shape, is nicknamed the Cocoon Galaxy.

Such collisions don't simply result in destruction and distortion, however. The sheer force and energy created in the galactic crash is enough to generate bursts of star formation out of the interstellar dust and gas, seen here as glowing pockets of red. This red is caused by dense clouds of ionised hydrogen being illuminated by the light of hot, newborn stars. NGC 4490 is classified as a starburst galaxy, which means that stars are forming at a rate quicker than the stellar ingredients can be replenished.

A thin bridge of stars, not seen in this image, connects the two galaxies as they speed away from one another. This bridge stretches for more than 24,000 lightyears.

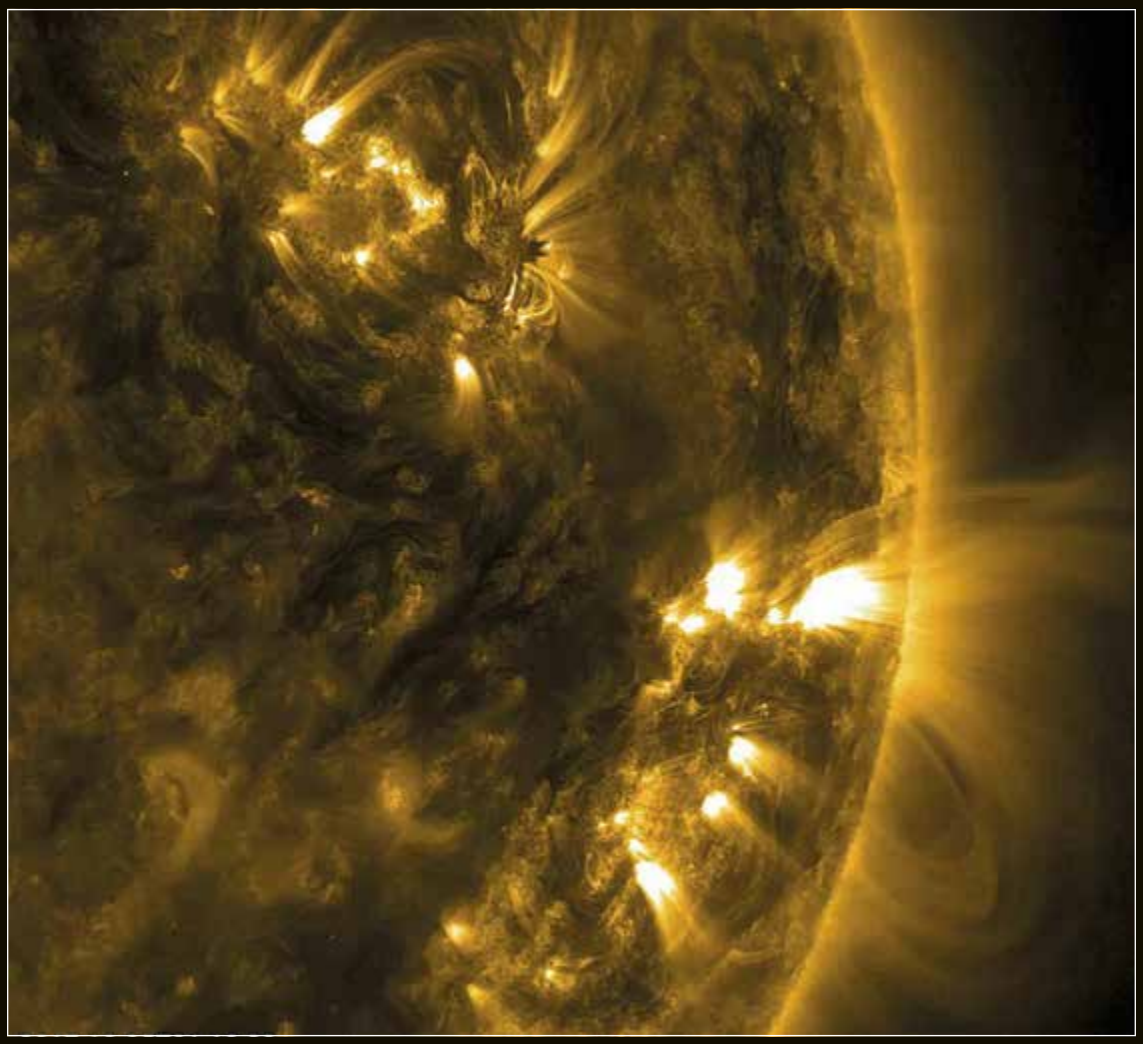
Perhaps our own Galaxy will go through a similar event one day. It is thought that our neighbouring Andromeda Galaxy will collide with the Milky Way in about four billion years, with a potentially similar fallout to what astronomers have observed here.

That's no planet... ▶

VERY LARGE TELESCOPE, 27 SEPTEMBER 2017

The Saturn Nebula is a planetary nebula, even though it has nothing to do with planets, let alone Earth's most famous ringed companion. Planetary nebulae form when stars of 0.8 to eight solar masses die, their cores collapsing into a white dwarf and their outer layers ejected into a diffuse gas shell, creating a circular shape that looks like a planet. Going by appearances, it's easy to see how this particular planetary nebula got its name.

◀ Dynamic duet



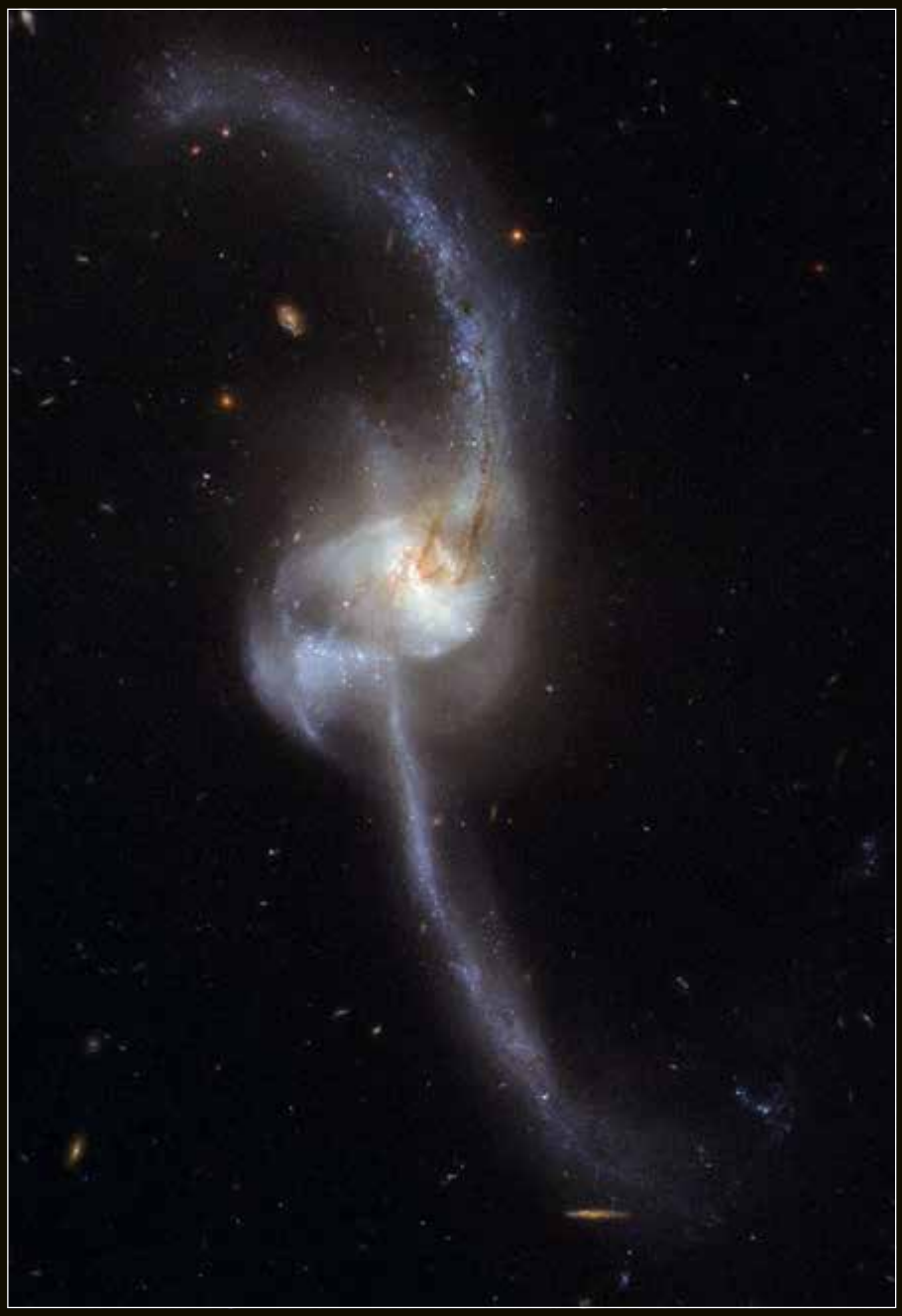
NASA SOLAR DYNAMICS OBSERVATORY, 4/5 OCTOBER 2017

These active regions on the Sun were captured by NASA's orbiting Solar Dynamics Observatory in ultraviolet light; a wavelength that can reveal plasma heated to over 1 million °C. The loops seen bursting out from the Sun's surface are charged particles spinning along magnetic field lines.

YOUR BONUS CONTENT

A gallery of these and more stunning space images

ESO/J. WALSH; NASA/GSFC/SOLAR DYNAMICS OBSERVATORY; ESA/HUBBLE & NASA; ALMA (ESO/NAOJ/NRAO)/S. KRAUS (UNIVERSITY OF EXETER, UK); NASA/JPL-CALTECH/SWRI/MSSS/ROMAN TKACHENKO



◀ Tails of two galaxies

HUBBLE SPACE TELESCOPE, 16 OCTOBER 2017

This bizarre-looking object is NGC 2623, the product of a galactic crash. It's located 250 million lightyears away in Cancer. The two arms spreading out into space are known as tidal tails, and they were formed during a brief period of the collision in which the galaxies orbited one another. The force generated by this motion caused material to be flung off into space.

▲ Carving out an orbit

ATACAMA LARGE MILLIMETER/ SUBMILLIMETER ARRAY, 16 OCTOBER 2017

Circumstellar discs are rings of gas and dust around young stars, and they often coalesce into planets. The star you see here, V1247 Orionis, appears to have two: a bright inner ring and a wider, fainter one farther out. The dark gap in between is thought to be caused by a young planet orbiting the star, carving a path through the material as it does so.

Satellites of a gas giant ▶

JUNO SPACECRAFT, 6 OCTOBER 2017

NASA's Juno spacecraft is in orbit around Jupiter, sending back data that is helping scientists unlock the secrets of the Solar System's largest gas giant. In this image, Jupiter's limb can be seen top right, its moons Io (right) and Europa (left) dwarfed in comparison. This image was processed by citizen scientist Roman Tkachenko using raw data captured by Juno.

Stay on track during observations

NEW

Omegon Pro Dobsonian telescopes - with friction system and deluxe equipment

8"-16" APERTURE - *Plenty of light for your introduction to the world of star clusters, nebulae and galaxies*

2" CRAYFORD FOCUSER - *For sensitive focusing, with 1,25" reduction and 1:10 dual speed*

FRICTION SYSTEM - *Achieve precise adjustments as smooth as butter*

PRIMARY MIRROR - *94% enhanced coating*

NEEDLE BEARINGS - *Super-smooth movements in azimuth, one finger push*

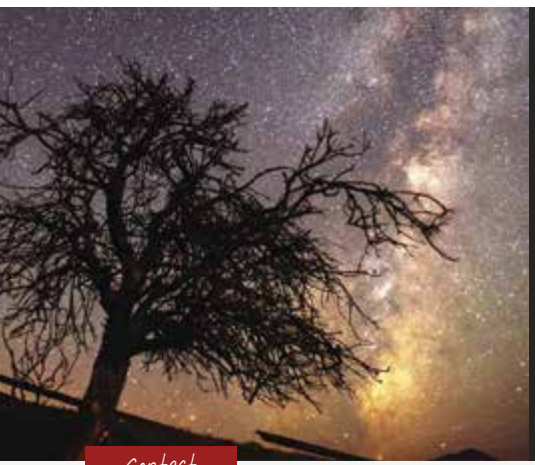
FAST COOLDOWN - *Cooling fan for primary mirror*

Available in four sizes:

54680 Omegon Pro **8"** Dobsonian	**£530.00**
54681 Omegon Pro **10"** Dobsonian	**£670.00**
54683 Omegon Pro **12"** Dobsonian	**£850.00**
54684 Omegon Pro **16"** Dobsonian	**£2,140.00**

Enter the product number in the search field.

> Learn more now on Astroshop.co.uk!



SO YOU CAN ALWAYS STAY ON TRACK, WHILE OBSERVING.

Omegon Pro Dobsonian telescopes ensure your observing nights go smoothly. Their new friction system makes precise setting and tracking of astronomical objects even simpler. Instead of Teflon pads, the axes are equipped with needle roller bearings in azimuth and ball bearings in altitude. This allows you to move the telescope around even more easily - it smoothly follows your every input in any direction. Keep astronomical objects in the field of view even at high magnification - a tremendous advantage!

Contact

Address
Astroshop.co.uk · c/o nimax GmbH
Otto-Lilienthal-Straße 9 · 86899 Landsberg · Germany

Phone
+49 8191 94049-61

Mail
service@astroshop.co.uk

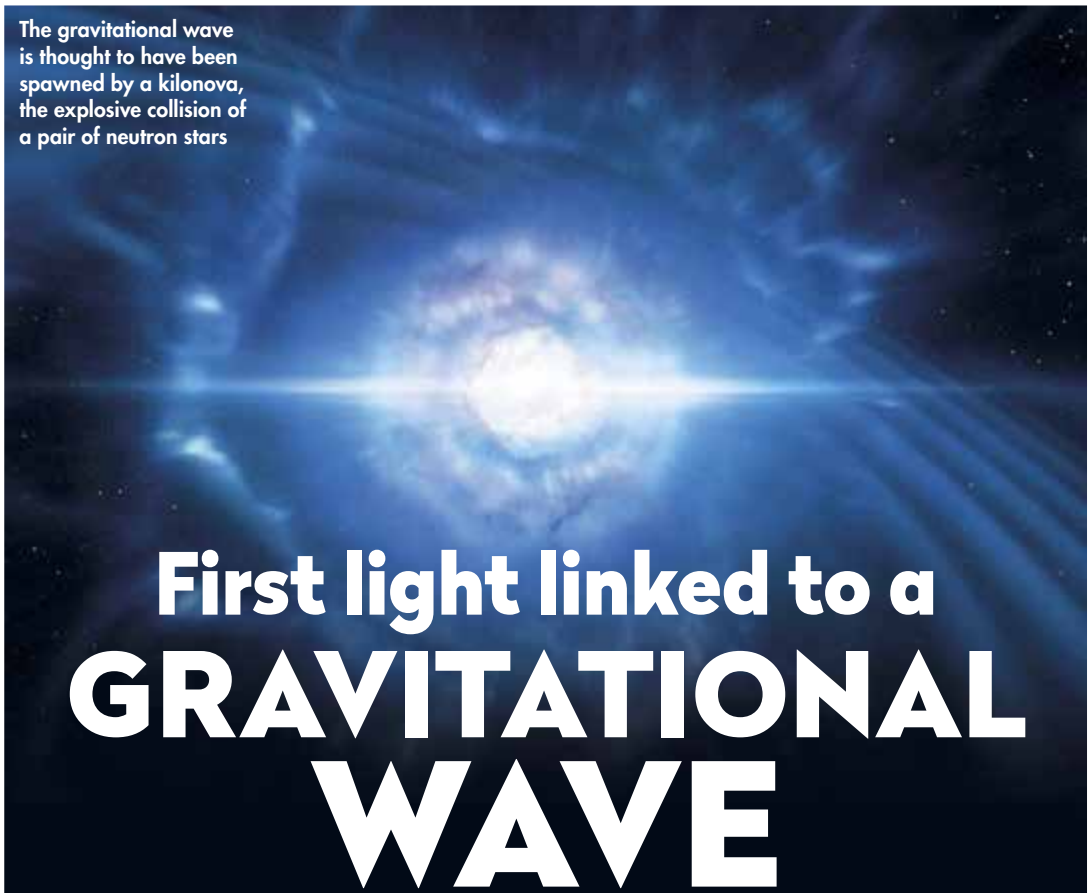
Astroshop.co.uk

Bulletin

The latest astronomy and space news written by **Elizabeth Pearson**

PLUS CUTTING EDGE

Our experts examine the hottest new astronomy research papers



The gravitational wave is thought to have been spawned by a kilonova, the explosive collision of a pair of neutron stars

ESO/L. CALÇADA/M. KORNMESSER

First light linked to a GRAVITATIONAL WAVE

The wave is also the first from colliding neutron stars

The first ever light from the source of a detected gravitational wave has been observed. The light, believed to have been created by two neutron stars crashing together, was picked up by the Laser Interferometry Gravitational-Wave Observatory (LIGO) on 17 August 2017, and located somewhere in a 30 square degree area of southern sky.

"We knew this wave was special as soon as it was announced," says Stephen Smartt of Queen's University Belfast, who led part of the follow up observations. "It lasted 60 seconds in the detectors, but the previous signals from black hole mergers lasted less than a second. Then two seconds after it finished we had a gamma-ray detection, which immediately alerted the LIGO team that this was something quite different."

Earthbound and space-based telescopes began tracking down a visible counterpart to the event and soon saw a new source of light in a galaxy 130 million lightyears away, NGC 4993. "I've never seen anything like this before," says Smartt. "It faded and turned red really quickly. This matched what some people thought we might see when it comes to what's called a kilonova – the signature from a neutron star merger."

The find is a new dawn for 'multi-messenger astronomy', which combines gravitational, electromagnetic and particle observations.

"The gravitational waves elucidate the strong gravity environment of the merger, invisible to telescopes," says Gregg Hallinan of CalTech, who also conducted follow up observations. "The electromagnetic radiation tells us how the explosion evolves, forms the heavy elements, and then interacts with and enriches the surrounding interstellar medium. This complete story – both hearing [via gravitational waves] and seeing the violent universe – is the gift of multi-messenger astronomy."

▸ **See Comment, right**

COMMENT

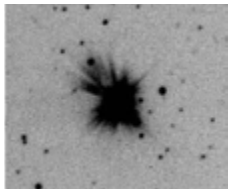
by Chris Lintott

The announcement of the detection of a neutron star merger, not only by gravitational wave experiments but also by myriad observatories, revealed what must have been the field's worst kept secret. Between LIGO and VIRGO team members, observers following up on the gamma-ray burst detected by Fermi and those scrambling to look for optical counterparts of the gravitational wave, half of astronomy has been talking about this for months.

That's the point, really. It's by combining information from different observatories that we really get to understand what's going on. In a single set of observations, we've seen an event never before observed, got clues into where the precious metals on Earth come from, bolstered explanations of gamma-ray bursts (but also raised new questions), found a new way of measuring the expansion of the Universe and shown that gravity and light travel at the same speed.

CHRIS LINTOTT co-presents *The Sky at Night*

NEWS IN BRIEF



BRIGHTEST NOVA APPEARS

The most luminous nova ever spotted has been observed in the Small Magellanic Cloud. The Swift space observatory discovered it on 14 October 2016 but have only recently announced the find.

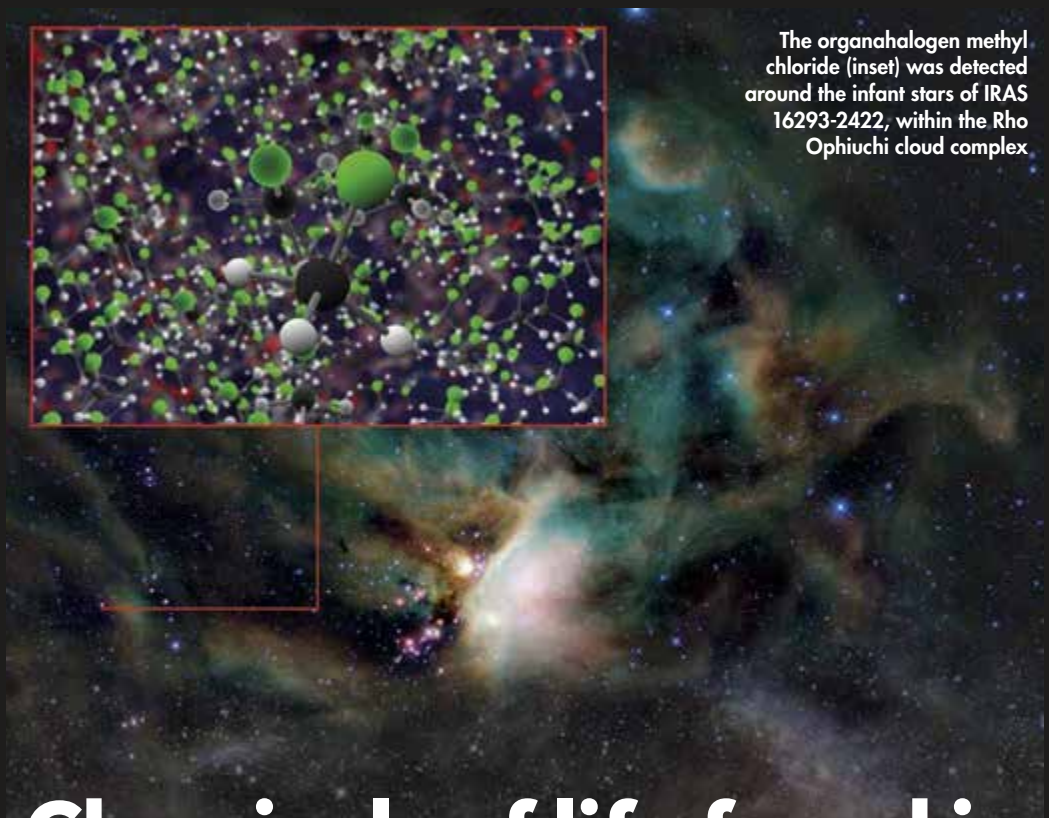
A nova occurs when an elderly white dwarf star steals material from a Sun-like companion star until it reaches a critical mass and bursts back into life. The white dwarf involved in this instance was close to its theoretical maximum mass, which may be why the resulting nova was so bright.

HELICOPTER THINKING

An algorithm used by helicopter designers to predict the flow of air around rotor blades has been adapted to help astronomers envision the turbulent movement of material around planets and galaxies.

"Space is full of gas, dust, fluids and turbulence," says Darryl Seigman from Yale University, who led the study. "We wanted to do a better job of accounting for the swirling of all this material. We were stunned by the level of detail we were able to achieve."

B. SAXTON (NRAO/AUI/NSF); NASA/JPL-CALTECH/UCLA, OGLE SURVEY, ISTOCK, NASA/JPL-CALTECH/SPACE SCIENCE INSTITUTE, NASA/JPL-CALTECH, J. CHANG/PMO/T. MÜLLER/HDA, INSTITUTO DE ASTROFÍSICA DE ANDALUCÍA (IAA-CSIC)



The organahalogen methyl chloride (inset) was detected around the infant stars of IRAS 16293-2422, within the Rho Ophiuchi cloud complex

Chemicals of life found in interstellar space

The compound could be an important part of planet formation

The organic chemical methyl chloride has been found in interstellar space for the first time. The discovery could help us understand how the ingredients of life came to Earth, but is a blow to exoplanet researchers hoping to use the chemical as a sign of life on other worlds.

Methyl chloride, also known as Freon-40, is an 'organohalogen' – a compound containing, carbon, hydrogen and one of the elements known as halogens, in this case chlorine. On Earth, the molecule is created by living organisms and industrial processes. Such chemicals, which are produced biologically but not geologically, could be used as biomarkers and help to find life remotely – if you find them in the atmosphere of an exoplanet, there could be living organisms creating them. Yet the discovery of Freon-40 in interstellar space suggests that the chemical can form without the intervention of biology.

The Atacama Large Millimeter/Submillimeter Array (ALMA) uncovered the chemical around an infant star, IRAS 16293-2422.

"Finding the organohalogen Freon-40 near these young, Sun-like stars was surprising," says Edith Fayolle, a researcher with Harvard-Smithsonian Centre for Astrophysics who led the study. "We simply didn't predict its formation and were surprised to find it in such significant concentrations. It's clear now that these molecules form readily in stellar nurseries, providing insights into the chemical evolution of planetary systems, including our own."

The chemical was also found in the thin atmosphere of comet 67P/Churyumov-Gerasimenko by the Rosetta orbiter. As comets are the leftovers of planetary formation, this suggests that Freon-40 is an integral part of the way planets grow.

"ALMA's discovery of organohalogens in the interstellar medium also tells us something about the starting conditions for organic chemistry on planets," says Karin Öberg, also from the Harvard-Smithsonian Centre for Astrophysics and co-author of the study. "Such chemistry is an important step toward the origins of life. Based on our discovery, organohalogens are likely to be a constituent of the so-called 'primordial soup', both on the young Earth and on nascent rocky exoplanets."

Rather than being a sign of life, organohalogens could be a prerequisite to allowing it to evolve.
www.eso.org

The rain falls hard on Titan

Huge storms have left their mark on the moon's surface

Monsoons of methane rain flood the deserts of Saturn's largest moon, Titan, much more frequently than previously thought. A mammoth downpour seems to fall on the moon once every Titanian year, equivalent to 29.5 Earth years.

"I would have thought these would be once-a-millennium events, if even that, so this is quite a surprise," says Jonathan Mitchell from the University of California Los Angeles. "The most intense methane storms in our climate model dump at least a foot of rain a day, which is close to what we saw in Houston from Hurricane Harvey this summer."

▲ The discovery was made by radar; Titan's haze hampers direct observation

Alluvial fans, the cone shaped features usually associated with heavy rainfall on Earth, were recently spotted from 50-80° latitude in Cassini radar observations. This suggests that the weather on Titan depends on location just as much as it does on Earth.

https://saturn.jpl.nasa.gov

Parallax pinpoints Milky Way's far side

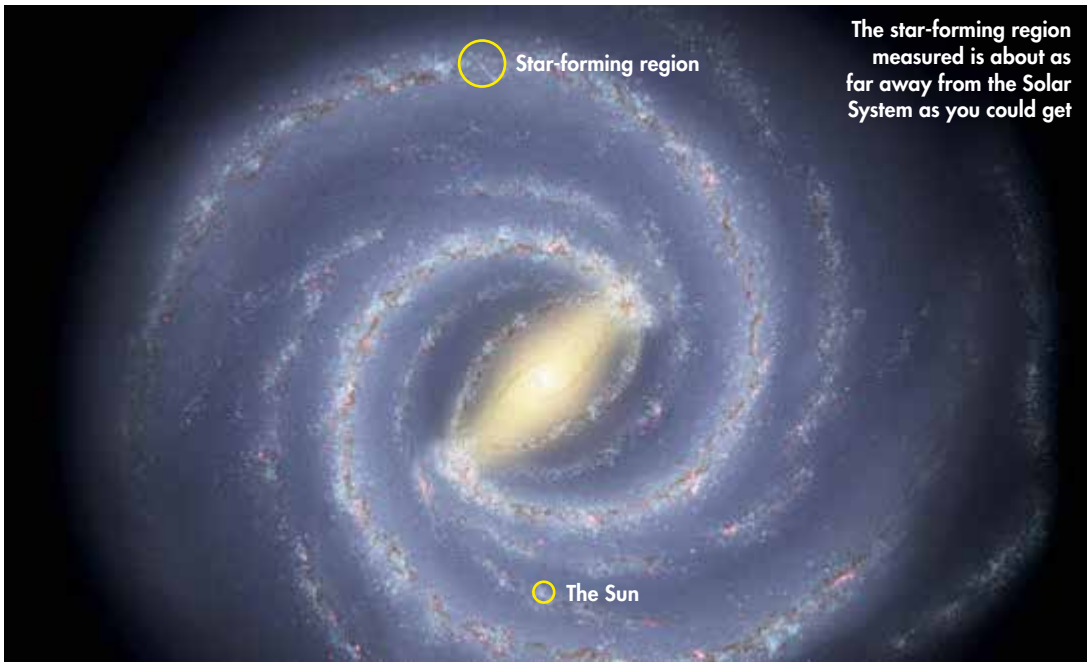
The longest distance measurement ever taken within our Galaxy has been achieved by the Very Long Baseline Array (VLBA), a network of 10 radio antennas across the globe to create one giant scope.

The readings pinpointed that a star-forming region on a distant spiral arm is 66,000 lightyears away. Astronomers used parallax measurements, calculating distance by measuring the apparent shift in sky position of a celestial object when observed from different locations on Earth. "This means that, using the VLBA, we can now accurately map the whole extent of our Galaxy," says Alberto Sanna, of the Max-Planck Institute for Radio Astronomy.

Previous efforts to map the Milky Way have been hampered by difficulties in measuring the location of objects on the far side of our Galaxy.

"Most of the stars and gas in our Galaxy are within this newly-measured distance from the Sun. With the VLBA, we now have the capability to measure enough distances to accurately trace the Galaxy's spiral arms and learn their true shapes," says Sanna.

https://science.nrao.edu/facilities/vlba



NEWS IN BRIEF

ASTRONOMERS IN A SPINDLE

A survey has shown that ultra-rare spindle galaxies might actually be relatively common. While examining the structure of 600 galaxies, the team from the Max Planck Institute for Astronomy found eight new spindles – properly known as 'prolate rotators' because these cigar-shaped galaxies rotate along their long axes. The strange galaxies are thought to form when two large disc galaxies collide and merge at right angles to create long, thin galaxies.

DWARF HAUMEA HAS RINGS

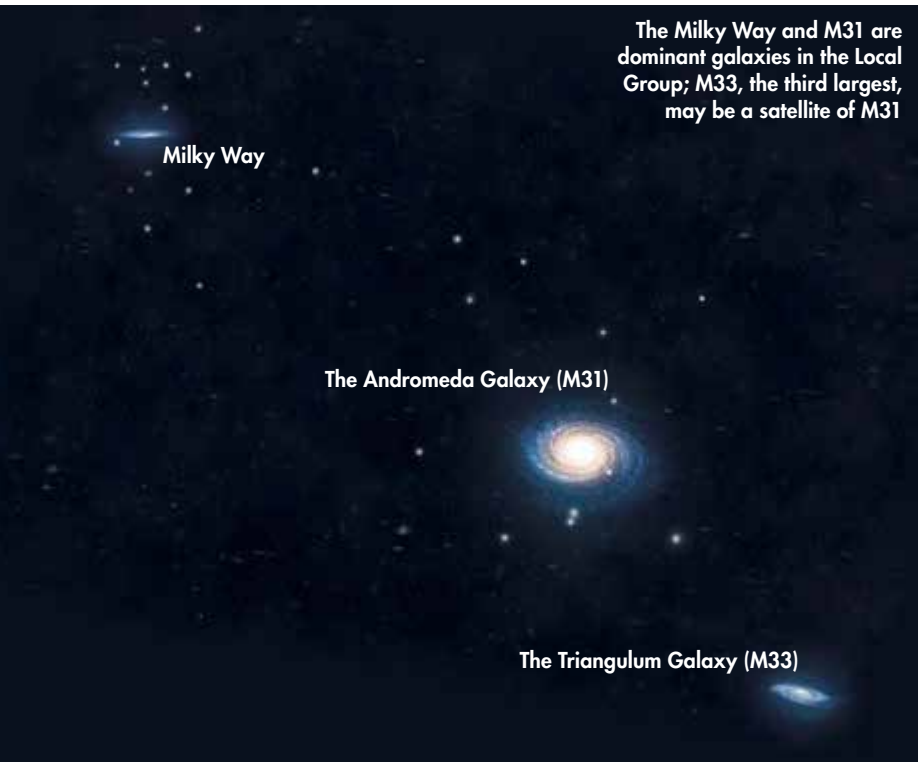
Rings have been seen around the dwarf planet Haumea. Astronomers watching the world as it passed in front of a distant star, noticed that the star's light dipped slightly before and after the main event, hinting at additional structure around the dwarf planet. "The analysis shows that these dips are explained by a narrow and dense ring around Haumea that absorbed about half of the incoming stellar flux," says Ulrich Hopp from the Max Planck Institute of Extraterrestrial Physics, who led the observations.

CUTTING EDGE

Our experts examine the hottest new research

The Universe appears to be inexplicably lopsided

Dwarf galaxies cluster between larger ones in the Local Group and elsewhere, but we don't know why



The Milky Way and M31 are dominant galaxies in the Local Group; M33, the third largest, may be a satellite of M31

MARK GARLICK

Our Local Group of galaxies is lopsided, and this has been worrying cosmologists. The group is made up of two large systems (Andromeda and our own Milky Way) and a host of smaller satellites, and it's the latter that are the problem. Rather than being distributed randomly, it turns out they are much more likely to be in the region between the two biggest galaxies than anywhere else, and it isn't immediately obvious why that should be the case.

The effect isn't small. About 80 per cent of the satellite galaxies that orbit around Andromeda are on the side that faces us, and similar effects have been seen around other pairs of large galaxies observed by the Sloan Digital Sky Survey. This result inspired a team led by Marcel Pawlowski in Irvine, California, to investigate whether the same thing happens in large-scale simulations of the Universe. If differences were found, it would suggest that something is wrong with our picture of how cosmology has steered the evolution of the Universe over the last 13.8 billion years. The currently favoured 'Lambda-CDM' cosmology already has problems accounting for lots of small-scale features of the Universe, such as the number of satellite galaxies seen, so a new test would be very welcome.

The experiment is an easy one to imagine. All you have to do is take one simulation of the Universe, and count the small galaxies that appear around pairs of massive systems within it. The authors used a suite of different simulations, torn between picking one that includes the smallest galaxies and choosing one that covers a large enough volume of the Universe to make for a good test.

We know much more about these simulated Universe than the real one. It is, for example, possible in the simulation to identify with cast-iron confidence which galaxies really are satellites of any given pair, while observers looking at the real thing might be confused by background galaxies that just happen to appear nearby. This problem is made worse because we only have estimated redshifts and hence distances for most of the smaller galaxies, but with some careful statistics the authors can make a sensible comparison.

> *"About 80 per cent of the satellite galaxies that orbit around Andromeda are on the side that faces us"*

When they do, it seems that in the simulations, just as in reality, the presence of a pair of big galaxies is associated with a lopsided distribution of smaller systems. The effect is seen in all but one simulation, and though that one is the most complex, including much more physics, it is also the smallest and so the absence of an effect is probably just coincidence. Cosmology passes the test, but we're still left with a mystery.

Satellites are most likely to be found between two large galaxies, but the next most likely simulated position is on the far side of each of the pair of galaxies. It's not at all clear why this is the case, or whether that effect holds in the real world. Plenty for both observers and theorists to get to grips with, therefore – even if cosmology passes the test this time.

CHRIS LINTOTT is an astrophysicist and co-presenter of *The Sky at Night* on BBC TV. He is also the director of the Zooniverse project.

CHRIS LINTOTT was reading… *The Lopsidedness of Satellite Galaxy Systems in ΛCDM simulations* by Marcel S Pawlowski, Rodrigo A Ibata and James S Bullock
Read it online at https://arxiv.org/abs/1710.07639

Kronos: destroyer of worlds

A metal-rich star could have engulfed 15 Earth's worth of rocky planets

We can only imagine what the worlds Kronos consumed might have looked like

A star may have devoured more than a dozen planets, according to the latest interpretations of its strange chemistry. The star, named Kronos after the child eating Titan of Greek mythology, is part of a binary pair with another star named Krios. Normally you would expect these stars to be twins, but Kronos is particularly rich in rock-forming elements such as aluminium, silicon and iron when compared with Krios. However, volatile elements which are commonly found as a gas, like oxygen and carbon, are not as abundant as you would expect if the cause of the difference stemmed from the star's age or origin.

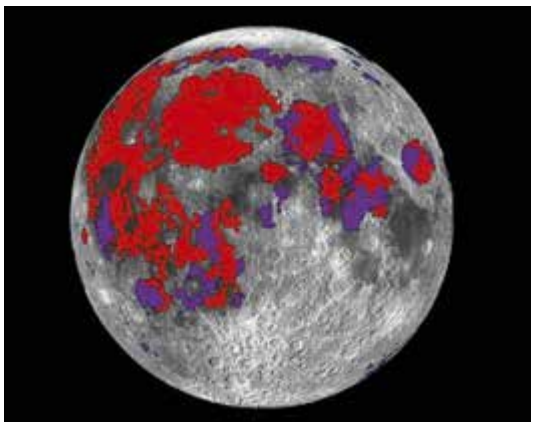
"All of the elements that would make up a rocky planet are exactly the elements that are enhanced on Kronos … so that provides a strong argument for a planet engulfment scenario," says Semyeong Oh from Princeton University, who led the study. **www.princeton.edu**

Volcanoes gave Moon an atmosphere

Ancient volcanic eruptions on the Moon produced a temporary lunar atmosphere four billion years ago, according to the latest analysis of Apollo moonrocks.

Today, any gases from geological activity on the Moon are lost to space at a far greater rate than they are produced, but during the Moon's peak volcanic activity enough gas was produced to accumulate an atmosphere that lasted about 70 million years.

"Although much of this vapour would have been lost to space, a significant fraction may have made its way to the lunar poles. This means some of the volatiles we see at the lunar poles may have originated inside the Moon," says Debra H Needham from NASA's Marshall Space Flight Centre. **www.nasa.gov**



▲ Three billion years ago lava flooded across the regions shown in red; purple regions are one billion years older

LOOKING BACK THE SKY AT NIGHT December 1996

On 8 December 1996, the team from *The Sky at Night* were looking at data from the Galileo probe, which had just completed its first year in orbit at gas giant Jupiter.

The first year hadn't been quite as prolific as Galileo scientists had hoped since the high-gain antenna, which transmits data back to Earth, failed to open properly after launch. The task was taken up by the low-gain antenna, which had a much slower upload speed.

Despite this, Galileo managed to achieve almost all of its science goals over its eight years at Jupiter. It completed 35 orbits of the planet discovering an intense belt of radiation above Jupiter's cloud tops and a strong magnetic field around the moon Ganymede. It also observed the interaction between the planet's electric and magnetic field, and the atmosphere of volcanic Io.

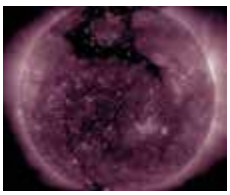
▲ Galileo completed 35 orbits of Jupiter over eight years

NASA/JPL-CALTECH/R. HURT (SSC-CALTECH), NASA/MSFC/DEBRA NEEDHAM/LUNAR AND PLANETARY SCIENCE INSTITUTE/DAVID KRING, NASA/JPL-CALTECH, SDO/NASA

NEWS IN BRIEF

SKY AT IAS

BBC Sky at Night Magazine met readers at this year's International Astronomy Show in Warwickshire in October. Over 2,000 visitors came to take a look at the latest telescopes and hear talks from astronomy experts – including *The Sky at Night*'s Chris Lintott and Mark Craig, director of *The Last Man on the Moon* – and 270 local Year 9 students came to learn more about infrared astronomy during an outreach morning at the show. Next year's event will be held on 12-13 October 2018.



AURORAE SURPRISE

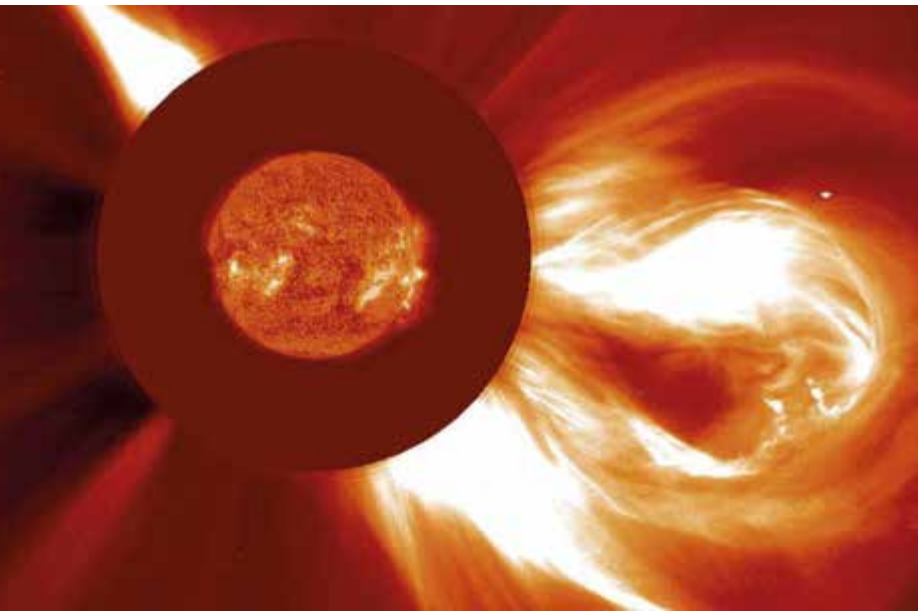
Bright aurorae danced across the sky between 9-15 October, despite a blank solar disc. The light shows are driven by space weather and conditions that week were remarkably stormy, despite the fact that the Sun had no sunspots or flares – the usual culprits of increased activity. Instead, an invisible coronal hole in the Sun's magnetic field allowed the solar atmosphere to escape. Aurora hunters hadn't been expecting such a spectacular show as the Sun is now in a patch of low activity.

CUTTING EDGE

Our experts examine the hottest new research

Does Earth need a solar shield?

We talk frequently of the asteroid threat, but perhaps we should do more to protect Earth from solar storms



SOHO/NASA & ESA

▲ **A large CME could wreak havoc on Earth's satellite network**

The Sun nurtures all life on Earth, but its fractious and sometimes violent nature also threatens our industrialised, technological civilisation. Consider the large coronal mass ejection (CME) that struck Earth in 1859, known as the Carrington Event after the British astronomer who observed the associated flare on the Sun's surface. When that CME hit Earth's magnetosphere it triggered auroral displays as close to the equator as the Caribbean, and induced a huge geomagnetic storm that caused sparks to fly from telegraph wires.

That was in an essentially pre-electric world; the damage inflicted on the world today by a similar event would be catastrophic. In particular, an extreme solar outburst could knock out satellite communications and global positioning systems (which are used nowadays not just for navigating your way around, but also for the timing signal used in many financial transactions) as well as inflict severe damage to electrical power grids, which could take years to repair.

It's been estimated that were the Carrington Event to hit the world now, it could cause a total global economic loss of up to $10 trillion. So what might we realistically be able to do to protect Earth from the impact of a CME?

Manasvi Lingam and Abraham Loeb at the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts, have explored the plausibility of humanity building an electromagnetic deflector in space to shield the Earth. Their paper is intended more to highlight the very real hazard posed by CMEs, which the authors say has not received as much attention as asteroid impacts or terrestrial natural disasters, rather than to propose a fully-planned engineering solution. But Lingham and Loeb do present some first-order physics calculations to work out what might be required.

If an electromagnet were placed at the L1 Lagrange point between the Sun and Earth, where the gravitational and centripetal forces are balanced, it would not need to be very powerful to deflect a CME around the planet: only around 0.01 per cent of Earth's magnetic field strength would be enough.

Even so, this would demand a huge amount of power whilst the shield was switched on (although this electricity could be provided by solar panels) and a colossal electromagnet coil structure to be assembled in space. The authors calculate that if the deflector coil were constructed with copper wire it would need about 100,000 tonnes of the metal (200 times more than the International Space Station) to be launched. They also estimate the launch cost to be around $100 billion, comparable to the total price tag of the ISS. These figures could be reduced if a superconducting coil were used instead, or perhaps the necessary materials were mined from an asteroid rather than launched from Earth. But either way, this would be certainly a large commitment.

> ***"Were the Carrington Event to hit the world today, it could cause a total global economic loss of up to $10 trillion"***

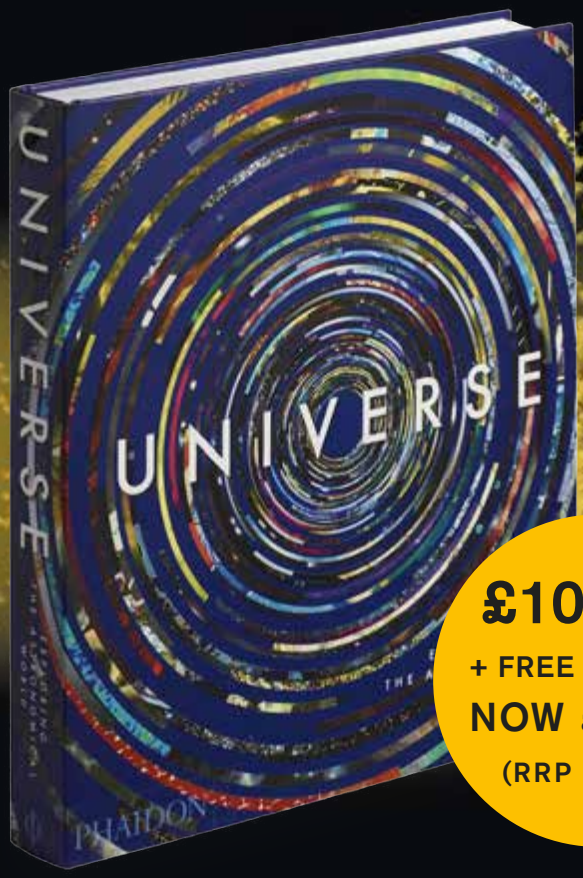
Building a giant space deflector shield might sound like something straight out of sci-fi, but the authors stress that it can be built with current technology, and at a fraction of the cost of the economic losses that could be inflicted if we did nothing. This might well represent a very sensible insurance policy for us all.

LEWIS DARTNELL is an astrobiology researcher at the University of Westminster and the author of *The Knowledge: How to Rebuild our World from Scratch* (www.the-knowledge.org)

LEWIS DARTNELL was reading… *Impact and mitigation strategy for future solar flares* by Manasvi Lingam and Abraham Loeb
Read it online at https://arxiv.org/abs/1709.05348

PHAIDON

SPECIAL OFFER



£10 OFF
+ FREE DELIVERY
NOW £29.95
(RRP £39.95)

This groundbreaking book features 300 inspiring images over 350 pages, chosen by an international panel of experts led by astronomer Paul Murdin.

"What makes this book unique is that as well as the breath-taking images taken with telescopes and the drawings of historical astronomers, it also includes the creative representations that have sprung from the minds of artists."
– *The Observer*

ORDER YOUR COPY TODAY AND SAVE £10 + FREE DELIVERY*

Buy online www.phaidon.com/universeoffer
Call FREEPHONE 0808 168 9598 and quote 'UNIVERSE'

Offer available while stocks last. Please note that all prices are subject to alteration without notice.
*Free delivery within the UK only. Hardback, 352 pp, 290x250mm, ISBN: 9780714874616.

Sales reps are available by phone or Live Chat 1400 and 2400 GMT
08-800-8989-0123

Everything for the Amateur Astronomer

ORION®
TELESCOPES & BINOCULARS

SINCE 1975 42nd year

FREE SHIPPING *on order of £100 or more*
Economy Shipping. Some exclusions apply.

OR

£7.95 FLAT-RATE SHIPPING
No minimum order. Some exclusions apply.

NEW PRODUCTS


Orion® LHD 80-Degree Lanthanum Ultra-Wide Eyepieces
£256 ea.


228-263mm ID Orion® PinPoint Telescope Focusing Mask
#40012 **£26**


Orion® SteadyPix™ EZ Smartphone Photo Adapter
#5347 **£83**


Orion® 6" f/4 Newtonian Astrograph Reflector Telescope
#10269 **£394**


Orion® ShoreView Pro II 8x42 ED Waterproof Binoculars
#51692 **£169**


Orion® GrandView™ Vari-Angle 20-60x80mm Zoom Spotting Scope
#40909 **£370**


Orion® 1.25" Twist-Tight Dielectric Mirror Star Diagonal
#40901 **£126**


Orion® 2" Twist-Tight Dielectric Mirror Star Diagonal
#40902 **£199**


Orion® StarShoot™ AutoGuider Pro & 30mm Ultra Mini Guide Scope
#20704 **£416**

HOT PRODUCT 2017 SKY & TELESCOPE


Orion® 60mm Multi-Use Guide Scope with Helical Focuser
#13008 **£164**


Orion® StarBlast™ II 4.5 Equatorial Reflector Telescope
#9250 **£192**

Astronomy magazine Star Products


Orion® Atlas™ Pro AZ/EQ-G Computerized GoTo Mount
#10010 **£1,832**


Orion® 8" f/8 Ritchey-Chretien Astrograph Telescope
#8267 **£950**


Orion® StarSeeker™ IV 127mm GoTo Reflector Telescope
#13163 **£576**

Trust
Proven reputation for innovation, dependability and service… for over 42 years!

Superior Value
High quality products at affordable prices

Wide Selection
Extensive assortment of award winning Orion brand products and solutions

Customer Support
Orion products are also available through select authorised dealers able to offer professional advice and post-purchase support

Retail prices shown are current as of 09/10/17 from Orion. Product prices include VAT. Prices are subject to change without notice. Please check ***OrionTelescopes.co.uk*** *for the most current pricing. Dealer pricing and/or promotions may vary.*


Orion® Mini Giant 15x63 Astronomy Binoculars
#9466 **£236**

HOT PRODUCT SKY & TELESCOPE


Orion® StarShoot™ G3 Deep Space Color/Mono Imaging Camera
#53082, 53083 **£398**


Orion® XT6 Classic Dobsonian Telescope Kit
#20557 **£288**


Orion® StarSeeker™ IV 150mm GoTo Reflector Telescope
#13161 **£473**


Orion® Atlas™ 8 EQ-G Reflector Telescope with GoTo Controller
#24732 **£1,571**

HOT PRODUCT SKY & TELESCOPE


Orion® SkyQuest™ XT10g Computerized GoTo Dobsonian
#10135 **£1,123**


Orion® SkyQuest™ XT8 PLUS Dobsonian Reflector Telescope
#8974 **£432**

Astronomy 2016 Star Products

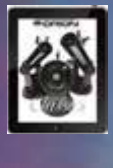

Orion® Monster Parallelogram Binocular Mount & Tripod
#5752 **£452**

ORION AUTHORISED DEALER

Telescope House
Edenbridge, Kent
01342 837 098
sales@telescopehouse.com
www.telescopehouse.com

Orion Telescopes & Binoculars now accepts the following payment options:

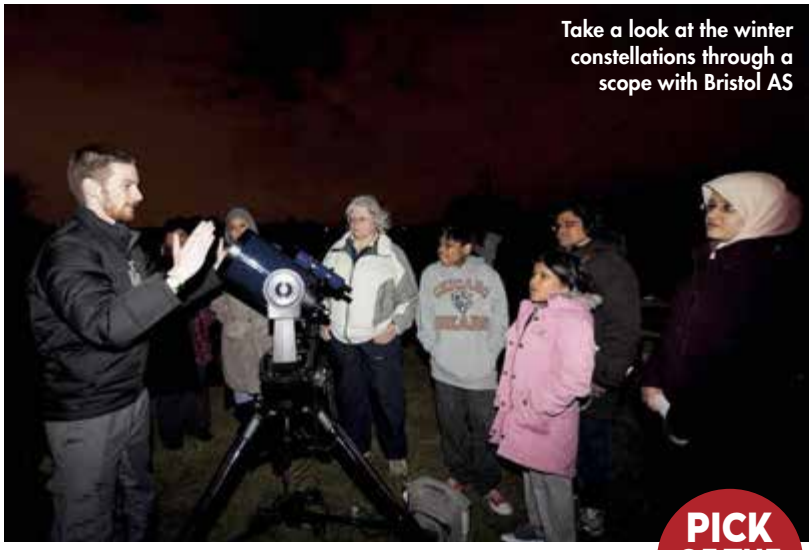
mastercard VISA AMERICAN EXPRESS PayPal bacs



OrionTelescopes.co.uk
Shopping has never been easier.
To learn more about Orion products and see a larger assortment, please check out the digital **eCatalogs** on our website!

What's on

Our pick of the best events from around the UK



Take a look at the winter constellations through a scope with Bristol AS

PICK OF THE MONTH

Bristol Christmas Star Party on the Downs

11-13 December, 7pm

Wrap up warm, get your scarves and hot flasks at the ready and prepare for a night of stargazing on the Downs with Bristol Astronomical Society, run in conjunction with the Friends of the Downs and Avon Gorge. Have a look through society members' telescopes and see the Orion Nebula up close; learn how to spot the winter constellations, and hear the stories written in the stars with a unique festive twist.

Joining Bristol Astronomical Society will be Shaaron Leverment and Ben Brown from UK hands-on science group Explorer Dome. Together, they will seek to make the evening fun and informative for young and old, and experienced amateurs and beginners alike. As the event takes place mid-December, you'll also be invited to sing some star-related festive songs and warm up with a hot drink and a star-shaped cookie (included in the entry price).

Tickets are £7.50 for adults and £4 for children, and can be booked in advance, but will be paid for on the evening. Please make sure you are free on all three evenings to avoid disappointment, as the winter weather may make some nights unsuitable for stargazing.

Book with the Avon Gorge & Downs Wildlife Project at Bristol Zoo on 0117 903 0609 or e-mail mleivers@bristolzoo.org.uk. You can also follow the event on the Wildlife Project's Facebook page.
www.facebook.com/avongorge

BEHIND THE SCENES

THE SKY AT NIGHT IN DECEMBER

BBC Four, **10 December,** 10pm (first repeat BBC Four, **14 December,** 7.30pm)*

Learn the basics of buying a telescope in the December episode of *The Sky at Night*

WONDERS OF THE NIGHT SKY

The Sky at Night's Christmas special this year is a beginner's guide to astronomy. Maggie explains the science behind the Northern Lights, Chris looks at how to navigate using the stars, and Pete shows us some night-sky highlights. Plus, advice on what equipment to buy and how to get the most from it.

Check www.bbc.co.uk/skyatnight for subsequent repeat times

A Beginner's Guide to the Night Sky

Royal Observatory Edinburgh, 18 December, 7.30pm

Join astronomers at the Royal Observatory Edinburgh for an introduction to the night sky. The event will also include a round up of recent astronomy news and the science of celestial sights. It's a perfect opportunity to ask any questions you have about observing. Admission is £4 for adults, £2 for children and concessions. Visit the observatory website to book tickets.
www.roe.ac.uk/vc

British Astronomical Association Christmas Lecture

Strand Campus, King's College London, 9 Dec, 1.45pm

This year's BAA lecture sees Prof Martin Barstow discuss the Hubble Space Telescope, and look at its potential successors. Dr Christian Trenkel delivers a talk on gravitational waves and how ESA's space-based LISA observatory will detect them. Entry is free for members and those booking before 20 November; £5 otherwise. Phone 020 7734 4145 or visit the BAA website.
https://britastro.org/xmaslecture2017

Moon Shadow: The Great American Eclipse

Bell Lecture Theatre, Queen's University Belfast, 13 December, 7.30pm

Two past presidents of the Irish Astronomical Association, Dr Andy McCrea and Terry Moseley, report on their successful trips to observe last summer's total solar eclipse in the US. They will show images and videos of the eclipse, together with a travelogue of the highlights of their visits. Admission is free and includes light refreshments.
www.irishastro.org.uk

MORE LISTINGS ONLINE

Visit our website at **www.skyatnightmagazine.com/whats-on** for the full list of this month's events from around the country.

To ensure that your talks, observing evenings and star parties are included, please submit your event by filling in the submission form at the bottom of the page.

The Infinity

For stunning views in seconds.

The Infinity breaks the barrier between visual observing and astrophotography. It combines the experience of observing at the eyepiece with a level of depth and detail that would traditionally be the result of several hours processing. This takes a camera that's sensitive enough to capture faint details on distant objects, and fast enough to do it in real time. It then takes our powerful, intuitive software to bring stunning views of the night sky to a screen in just seconds.

This recreates the feel of observing in the field through a very large telescope, only using much more modest equipment. You stay connected to the night sky, watching satellites drift across your field of view, while viewing objects previously out of reach to all but the most powerful eyepieces and the largest apertures.

See the faint connecting filaments in M51 while planning your next move in your star atlas. See bok globules in the Pelican Nebula as you dodge the clouds. Dive deep into the NGCs of Andromeda - and do it all in colour.

Although our eyes aren't sensitive enough to see the universe in colour, the Infinity is. Faint grey fuzzies become detailed areas of colourful nebulosity, allowing you to go beyond the limits of our vision.

But our own vision isn't our only limitation. Light pollution is a growing problem for all of us, with backyard observing becoming increasingly difficult in many places. The Infinity helps you cut through the pollution to bring observing back to our urban areas.

It also helps you share the breath-taking things we see and discover as astronomers. By cutting the queue to the eyepiece, the Infinity allows everyone to explore the night sky not just together, but at the same time. You can discuss details and anomalies as you see them, and remove the need for special skills in averted vision.

This makes it the perfect tool for public outreach, as well as observing with family and friends. But the Infinity doesn't just provide you with incredible live views. It also allows you to save single images and even whole sessions to share later. You can even broadcast your session live online to a global audience, right from inside our software.

But surely something this advanced involves additional specialist equipment and complex software? That's the best bit. The Infinity is designed to work from a focal length of around 300mm right through to 1500mm. It works with alt/az fork-mounted telescopes as well as equatorial mounts. As long as you can track a star for a few seconds, it will work with an Infinity, without the need for complicated guiding systems.

The camera itself uses the latest in CCD technology to provide incredible sensitivity at very low noise, and it's all controlled through our custom built software. You want to spend your time exploring the universe, not learning our program, so we've kept it as simple and intuitive as possible while still giving you the power and control you need to delve deep into the night sky.

Want to know more?

Find us at:

www.atik-cameras.com

ATIK CAMERAS

Atik Cameras are available from most major astronomy retailers. For a full list of stockists, visit us online.

A PASSION FOR SPACE

with **Maggie Aderin-Pocock**

The Sky at Night presenter hails a new age of astronomy in the wake of the latest gravitational wave detection

Following the first announcement that gravitational waves had been detected in February 2016, I speculated about the timescales needed for this new area of astronomy to take off. It took the two LIGO instruments 14 years to detect their first wave and having done the trick once, I was interested in how long it would take to detect the next one.

Two tiny yet dense neutron stars collided to create the kilonova, which we saw as a gamma-ray burst and a gravitational wave

My wait was a short one: a faint signature of these ripples in space-time was detected just four months later and three more confirmed detections were announced within 18 months of the first – one by the European counterpart of LIGO, an instrument called Virgo. The latest gravitational wave detection, announced on 16 October, is the most impressive of all: not only was the gravitational wave detected, but within seconds of it an electromagnetic signature was also recorded from an overlapping part of the sky.

Rather excitingly, this electromagnetic signature was a gamma-ray burst, the brightest source of electromagnetic waves in the Universe. Its detection marks a milestone in astronomy since it means that the event was not just observed by the LIGO and Virgo gravitational wave detectors, but also independently witnessed by NASA's Fermi and ESA's Integral space telescopes.

The joint detection sheds light on the mystery that is gamma-ray bursts. These highly energetic emissions are transitory, lasting from a few milliseconds to a few hours, and there has been much speculation about their nature. But from this joint detection the source of the eruption appears to be the collision of two neutron stars.

The age-old question

Gravitational waves were a prediction of Einstein's 1915 general theory of relativity, so how come it took over 100 years for the first observation to be made? The answer lies in the size of the signal that the gravitational wave detectors are trying to pick up. The passing of a gravitational wave causes a very distinct signature in space-time: first it is elongated in one dimension while being compressed in another, then the reverse happens. While this may be unique, the size of the movement is smaller than a proton. Detecting a signal this size above any noise present is challenging, but it is achieved using a device called an interferometer. In this, a beam of light travels down two perpendicular, L-shaped arms in the detector. The length of this path (4km for LIGO, 3km for Virgo) means the instrument can detect minute perturbations: it's the equivalent of measuring the distance between us and Alpha Centauri (some 41 trillion km away) and being able to detect a change in that distance equivalent to the width of a human being!

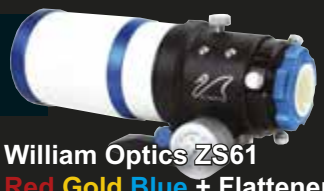
It is challenging stuff, but now we have detected gravitational waves multiple times and have independent verification, it is time to hail a whole new way of doing astronomy. I am sure that Einstein would have been very pleased.

► **Discover more about the historic October 2017 detection of gravitational waves on page 35 and page 106**

Maggie Aderin-Pocock co-presents *The Sky at Night* and *CBeebies Stargazing*

The Widescreen Centre

Merry Christmas from the UK's Astronomy Showroom - and Happy New Year 2018!



William Optics ZS61
Red Gold Blue + Flattener

• Quality • Choice • Expertise • Service •

The Widescreen Centre

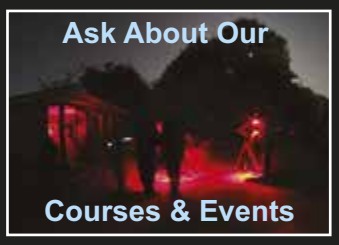
News & Events, December

Holiday Opening Hours:-

• Close Sunday December 24th
• Open Wednesday January 3rd
Last courier date: December 20th
Royal Mail Special Delivery: 21st

Astrofest 2018 is February 9/10th

Come and see us soon - check for December events or sign up for our newsletter by emailing simon@widescreen-centre.co.uk



Including one on one tuition. Want to learn more about Astronomy & telescopes? Why not attend one of our courses or events? Learn about beginning Astronomy, how to use your equipment, getting into imaging and more whilst enjoying the big skies of Cambridgeshire. Call or email us today and sign up for our Newsletter.

MEADE Vixen TeleVue Visionary baader planetarium CELESTRON Sky-Watcher

All the major brands under one roof and the best advice and expertise in the industry. From beginners of all ages through those returning to the hobby, to advanced imagers and professional installations Widescreen has all you will ever need. Compare the latest best-sellers and talk things over with one of our experts. We attend all major events on the UK's Astro calendar or see us monthly with London's Baker Street Irregular Astronomers! Considering a new purchase? Come and see us today.

The Widescreen Centre

01353 776199

Showroom: 2 Rosemary Lane • Sutton nr. Ely • Cambridgeshire • CB6 2NZ
www.widescreen-centre.co.uk • 07990 646466 • simon@widescreen-centre.co.uk

JON CULSHAW'S

EXOPLANET EXCURSIONS

Jon's travels take him to the scorching world as black as bitumen

Auriga, the Charioteer, is a prominent and familiar constellation in our winter night sky. A well-known and welcome icon in the sky during those long dark nights, it brings a reassuring feeling when we look at it. It's amazing, therefore, to consider that one of the most unnervingly unusual and extreme exoplanets exists within it.

Around the star Wasp 12 – a yellow G0 star of 1.4 solar masses and 1.6 solar radii, very similar to our own Sun – is the hottest of the 'hot Jupiters'. Gas giant planets of this class orbit tightly around their host stars and – quite naturally – are scorching and searing as a result.

The planet in question, Wasp 12b, is a mightily severe and hostile environment indeed. This month's trip promises to be exciting and nerve-wracking in equal measure. Described in terms that would suit the voice of Darth Vader, what manner of terrifying place could this "black hot Jupiter feasting upon light" possibly be?

After making the 871-lightyear journey to Wasp 12 it is staggering to see just how close this hot Jupiter is to its parent star; it completes a single orbit happens in roughly one Earth day. The proximity also bestows some intriguing effects. Wasp 12b is tidally locked for one, the same side always facing the star. The temperatures on its day side are around 2,500°C. This means that no molecules are able to form in its atmosphere, so there are no clouds to reflect the intense starlight from Wasp 12 back into space; it's likely that all of its light is absorbed deep into the planet and converted to heat.

It's this miniscule amount of reflection that's the reason why Wasp 12b is the darkest of exoplanets known. Looking at the intense blackness of the world's night side, it seems like a planetary sized lump extracted out of a mighty black hole using a cosmically scaled ice cream scoop.

The closeness of Wasp 12b's star also means that there's a merciless gravitational pull upon the planet, distorting it into an obvious oval shape and steadily stripping away its materials. It is disturbing to witness the bizarre events playing out for this planet close up, yet it's completely arresting too.

It evokes the feeling you'd get watching some hapless creature that ambled too close to a mantis-like ambush predator. Now it's locked into a destiny it cannot escape, being slowly consumed. Or perhaps it's like a planetary indigestion pill slowly dissolving and effervescing until its eventual disappearance.

It's all rather sad in a way: my trip in the Perihelion back to our backwater of the Milky Way feels like it's being conducted in a minor key. Next time, I think a place of soothing planetary harmony is required.

Jon Culshaw is a comedian, impressionist and guest on *The Sky at Night*

MAIN ILLUSTRATION: MARK GARLICK, SPACECRAFT: PAUL WOOTTON, PHOTO: EMMA SAMMS

Interactive

EMAILS ◢ LETTERS ◢ TWEETS ◢ FACEBOOK

Email us at **inbox@skyatnightmagazine.com**

This month's top prize: four Philip's books

PHILIP'S

The 'Message of the Month' writer will receive four top titles courtesy of astronomy publisher Philips: Robin Scagell's *Complete Guide to Stargazing*, Sir Patrick Moore's *The Night Sky*, Robin Scagell and David Frydman's *Stargazing with Binoculars* and Heather Couper and Nigel Henbest's *2018 Stargazing*.

Tales from THE EYEPIECE

Stories and strange tales from the world of amateur astronomy by Jonathan Powell

Tis the season for Christmas jumpers, hats and gloves! All of which are very welcome when observing on a cold winter's night. However, many moons ago, I spotted in a shop window a product labelled as a hand-warming device. Thinking this would be a great astronomical accessory, I duly purchased it. The 'hand warmer' was in fact several charcoal-coloured flat sticks, each measuring about five inches long, wrapped in a small polythene sheath! It transpired that the sticks needed to be placed in a far more expensive pouch that allowed the heat to be emitted safely. D'oh! So, if you're buying things to warm the hands of the astronomer in your life this Christmas, gloves are a safer bet. They shouldn't cost the Earth and indeed, they won't burn a hole in your pocket!

Jonathan Powell is the astronomy correspondent for the South Wales Argus

Badge of honour

MESSAGE OF THE MONTH

Our eight-year-old son, Sam, has been super interested in space and astronomy forever. It's something he and I discuss and explore all the time and we now have a nice telescope, which we don't use enough! Recently he made this model of the Solar System to gain his collectors badge and his astronomy badge at Cubs, and he describes it in his own words below...

"First I was beachcombing when I realised that I had to do a Collectors badge for Cubs. So I had an idea to create a model of the Solar System. I have included Mercury, Venus, Earth, Mars, the asteroid belt, Jupiter, Saturn, Uranus, Neptune, Pluto and Eris. Fun fact, Venus is the goddess of love and Phobos and Deimos mean fear and terror."

Andy, Sue, Grace and Sam Foster (aged 8), Warwickshire

What a fantastic way to show the planets and moons of the Solar System, Sam. I do hope that earned you your Cub Scout badges! ***– Ed***

▲ **Sam's beachcombed Solar System – a collage of space rocks of a quite different kind**

Eclipse inspiration

Following your article on processing solar eclipse images in the September issue (Image Processing, page 84) and the recent US eclipse, I went back to my original DSLR shots from the Faroes eclipse on 20 March 2015. I stacked the best 68 using the noise/alignment options in RegiStax and made some contrast adjustments. A Moon mask also vastly improved on single images. I normally use stacking for planetary work, but the article prompted me to revisit the archive to see if I could improve things. I'm very pleased with the results.

Anthony Fogg, via email

Tweets

Adrien Mauduit
@ADphotography24 • Oct 10
'Flowing towards new horizons' #auroraborealis in #iceland last week @B_Ubiquitous @photoweather1 @Extreme_Iceland @AuroraMAX @earthescope

It's great to hear that we helped you get more out of your images, Anthony! That's a nice final image. ***– Ed***

Light nightmare

Thank you for publishing the thought-provoking poster of the extent of light pollution over Britain and Ireland in the October 2017 issue. Until they see such images, many astronomers have little realisation of the extent of the problem, which, sadly, is not widely known about but threatens everybody's experience of the night sky.

Bob Mizon, Coordinator, British Astronomical Association Commission for Dark Skies (CfDS)

It's crucial that as many people as possible know that our night sky is slowly disappearing. For more, see the CfDS website at www.britastro.org/dark-skies ***– Ed***

Top trolley

Having recently drawn up my own design for a home-made trolley I was very intrigued to open the September issue to find Mark Parrish's similar design (How To, page 82). I've just finished it and so have only had a couple of sessions with it so far, but it certainly makes setting up a lot quicker and easier: not having to carry heavy equipment like an EQ6 head is a real benefit for my bad back! I'm hoping that this new setup will encourage me to use my telescope more often, particularly as we have had such changeable weather of late.

Jeff Hopton, Sutton Coldfield

That's a sturdy-looking platform, Jeff. The white finish ties it in really well with the EQ6 mount! ***– Ed***

Tweets

Alyn Wallace
@alynwallace • Oct 23
At sunrise it was a jostle of tripods, but at night, the lake was mine. The night sky of #LagoDiBraies welcomed me with open arms #Dolomites

Tweets

Julie Dickson
@dicksonjulie1 • Oct 13
Moon of 11th October.
@skyatnightmag @photos_astro @RichardXIII

Meanwhile on FACEBOOK...

WE ASKED: What was your biggest astronomical achievement in 2017?

Danny Sdso
Finding my favourite galaxy M51 the Whirlpool Galaxy for the first time (non Go-To mount) I love the thrill anytime I find a new DSO for the first time.

Andy Hearns
Managing to photograph the eclipse from Carbondale Illinois.

Al Higgs
Green fireball during the Perseid meteor shower this year.

Brendan Scoular
Seeing the total solar eclipse just north of Riverton, Wyoming. For 2017 this wins hands down!

Gordon Hogan
Getting a close up shot of the ISS for the first time. Couldn't get the smile off my face for a month!

Nikki Young
Capturing Space X's rocket boosters falling away on camera as it roared over the UK, 3rd June this year, some 30 minutes after launching in the US.

Gerard Mooney
Watching an eclipse on another planet for the first time (and actually managing to capture the event with my phone's camera!) Jupiter in April.

Paul Scott
Travelling to La Palma, Canary Islands. Driving in foreign country. Tracking up the side of a mountain in the dark to capture the Milky Way.

SOCIETY in focus

▲ **Astronomers at Haw Wood Farm**

Breckland Astronomical Society has been running spring and autumn star parties at the Haw Wood Farm caravan and camping site in Hinton near the Suffolk coast for several years. The parties have been slowly growing in size, with people coming from far and wide to enjoy the very dark skies available at this Dark Sky Discovery Site, where even the gegenschein has been seen!

The management goes to great lengths to ensure that everyone can enjoy the dark skies. All on-site lighting is covered or turned off, a red light policy is enforced and staff try to keep imagers and observers in separate areas. This year the week of 13 to 20 October was reserved for serious astronomers, and a separate public outreach event was held over the following school holiday weekend.

Although not as big as some other star parties, the Haw Wood Farm parties are highly regarded by some serious observers and several large Dobsonians are always in attendance! Being smaller makes these events more intimate and this year views through some of the largest telescopes were freely offered, with targets like the Crescent, Veil and Helix Nebulae clear to see. To add to Sky Quality Meter readings of 21.06, the weather this year was wonderful, with clear skies over the main nights.

David Murton, visiting from Orwell Astronomical Society Ipswich

BBC

Sky at Night MAGAZINE

SAVE WHEN YOU SUBSCRIBE TO THE DIGITAL EDITION

Available from

Download on the App Store

amazon apps Available on kindle fire

GET IT ON Google play

zinio™

The perfect addition to your stargazing, *BBC Sky at Night Magazine* is your practical guide to astronomy, helping you to discover the night skies, understand the Universe around us and learn exciting techniques for using your telescope.

Enjoy our Premium App experience now available from

Download on the App Store | amazon apps Available on kindle fire | GET IT ON Google play | zinio™

BBC

Sky at Night MAGAZINE

Hotshots

This month's pick of your very best astrophotos

YOUR BONUS CONTENT

A gallery containing these and more of your stunning images

▲ Harvest Moon

KEVIN JACKSON, SOUTHPORT, 5 OCTOBER 2017

Kevin says: "I love taking pictures of the Moon, so the full Harvest Moon was extremely appealing. I'm a back garden amateur astrophotographer and find lunar photography a great and easy way of learning basic astrophotography skills. I recently purchased a new scope and I am really pleased with the quality."

Equipment: Altair Hypercam IMX178C, Altair Astro Starwave 102 ED doublet refractor (2017 version), Astro Physics CCDT67 Telecompressor, EQ3-2 mount, Moon filter.

***BBC Sky at Night Magazine* says:** "We receive many excellent lunar images each month, but not all are as good as this! The level of detail in the smaller craters and the crispness of the rays really makes this one stand out. Kevin has achieved incredible resolution all the way to the limb and the contrasting colours of the lunar maria are superb."

About Kevin: "I've always enjoyed looking up at the stars on a dark night and picking out the more familiar constellations, but it was only in 2013 that I decided to purchase a Celestron NexStar 6SE with the intention of also capturing what I was seeing. As with anything astrophotography related, things quickly escalated. I started capturing images of the Moon with a DSLR and then turned my attention to another favourite: the Orion Nebula."

◀ The Milky Way

PETE COLLINS, CHATEAU DE ST GERMAIN DE CONFOLENS, FRANCE, 17 SEPTEMBER 2017

Pete says: "I shot this image of the Milky Way over the ruins of a 12th-century castle during a visit to Astrofarm in darkest rural France. Andrew Davies of Astrofarm told me the floodlights were turned off every night at 11.30pm, so I arrived at 11 to position the Milky Way where I wanted it, then waited for the lights to go out."

Equipment: Canon EOS 6D DSLR camera, Samyang 14mm lens.

▲ The Pleiades

PAUL BARRETT, ABERCANAID, MERTHYR TYDFIL, 2 SEPTEMBER 2017

Paul says: "The camera I had before this was a colour camera, so it was a bit of a steep learning curve. This was my first attempt using RGB – I did not use luminance."

Equipment: ZWO ASI1600 CMOS camera, Sky-Watcher Equinox 80 ED apo refractor, Sky-Watcher HEQ5 Pro SynScan mount.

The Heart and Soul Nebulae ▶

JONATHAN PEACOCK, WEST SUSSEX, 20 AUGUST 2017

Jonathan says: "The Heart and Soul Nebulae are two of the most stunning objects in the night sky. I was keen to capture both in one image and so opted for a wider field of view."

Equipment: PrimaLuceLab cooled Canon 700Da DSLR camera, Meade LX200 ACF 8-inch Schmidt-Cassegrain, Canon EF 100-400mm II lens.

▲ The Trifid Nebula

RAFAEL COMPASSI, PRESIDENTE LUCENA, BRAZIL, 19 SEPTEMBER 2017

Rafael says: "My friend lent me a QHY9 camera for testing, to see what kind of results I could get. I was impressed! The colour contrast is breathtaking."

Equipment: QHYCCD QHY9M mono CCD camera, Sky-Watcher Explorer-200DPS 8-inch Newtonian, Darío Pires equatorial mount, PicGoto++ controller.

The Cat's Paw Nebula ▶

MAICON GERMINIANI, SANTA CATARINA, BRAZIL, 1 AUGUST 2017

Maicon says: "As its name suggests, the peculiar shape of this emission nebula resembles a cat's paw. Located in Scorpius 5,500 lightyears away, it is a region of intense star formation, containing many young blue stars of high mass, formed in the last million years."

Equipment: ZWO ASI1600 CMOS camera, Teleskop Service 115/800 triplet apo refractor.

▼ The perfect beach

CARL GALLAGHER, WESTPORT, CALIFORNIA, US, 24 AUGUST 2017

Carl says: "The shot was taken on Pete's Beach in the small town of Westport, California after watching the Great American Eclipse. At about 11pm I wandered down a long-forgotten path to the beach by torchlight, and was greeted by a perfect inky black sky and the Milky Way framed by some spectacular rock formations."

Equipment: Canon EOS 6D DSLR camera, Samyang 24mm lens.

Pickering's Triangle ▶

GEORGES CHASSAIGNE, FREGENEAL DE LA SIERRA, SPAIN, 15 AUGUST 2017

Georges says: "The Veil Nebula is a cloud of heated and ionised gas in Cygnus. It constitutes the visible portion of the Cygnus Loop, a large but relatively faint supernova remnant. The Veil Nebula is a spectacular object in the summer sky. I chose this part because the field of my camera cannot capture all of the nebula."

Equipment: SBIG STX 16803 CCD camera, Astrosib 14-inch Ritchey-Chrétien, Astro-Physics 1600 Go-To mount.

▲ Cygnus wide field

PAUL GORDON, KELLING HEATH, NORFOLK, 25 SEPTEMBER 2017

Paul says: "I took this on the last evening of Kelling Heath Norfolk Star Party. I wanted to see how hard I could push the Star Adventurer mount without guiding and what ISO setting I could use that would still give a presentable image."

Equipment: Modified Canon EOS 1300D DSLR camera, Sky-Watcher Star Adventurer mount, Canon 50mm lens.

Naturetrek

Join us in Chile for the next total solar eclipse in July 2019

Naturetrek's astronomy and wildlife holidays combine some of the finest wonders of the night sky with expertly-guided wildlife and cultural excursions. Our Chilean Solar Eclipse itineraries include visits to astronomical observatories, guided-viewing of the southern sky and, for 'Eclipse Day', the best chance of ideal viewing conditions from our carefully chosen base high up in the Andes. These itineraries are both designed and accompanied by experts with a wealth of experience in this field.

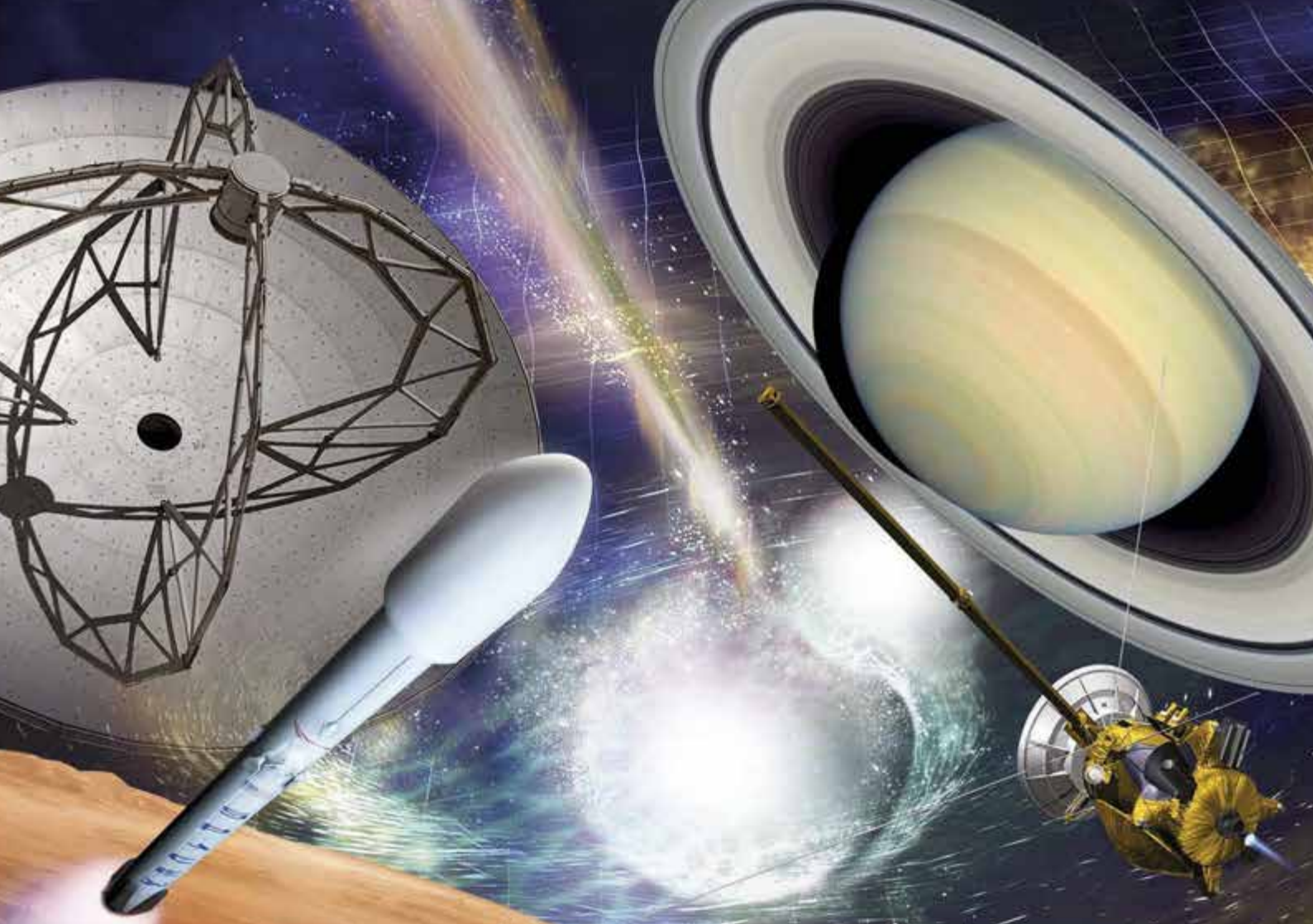
'Throughout my life I have travelled widely and seen many amazing sights. Few, though, compare with a total solar eclipse. These spectacular events transcend our terrestrial existence, connecting us with the wider Universe.'

David Phillips, Operations Manager

Visit us on Facebook

01962 733051 Google: "Naturetrek astronomy tours"

Naturetrek, Mingledown Barn, Wolf's Lane, Chawton, Hampshire GU34 3HJ



2017

A YEAR IN REVIEW

Cassini, SpaceX and gravitational waves have all grabbed headlines in the past 12 months

From Cassini's final days to imaging the Milky Way's centre, the past 12 months have been stellar for astronomy. Elizabeth Pearson looks back over 2017's great moments for space science

Sixty years ago, Sputnik 1 blasted off into orbit, kickstarting the Space Age. Now, in 2017, we have spacecraft orbiting around the planets of our Solar System, a fully crewed space station in low-Earth orbit, and huge telescopes probing the deepest corners of our Universe. In the past year, we have discovered new worlds around a distant star, bid a bittersweet farewell to an old robotic friend around Saturn and taken steps to extend humanity's reach farther and farther out into the Solar System.

As we approach the end of the year, it's time to look back and see what we've learned about our cosmos over the last 12 months. ▸

Cassini burned up in Saturn's eerily Earth-like blue skies

Cassini's GRAND FINALE

The probe was transmitting scientific data until its final moments

On 15 September, after a mission of 20 years, the Cassini orbiter met its end in Saturn's atmosphere. But it did not go quietly into the night. Instead, the spacecraft spent its last year performing some of the most audacious manoeuvres of the mission.

"At the start of the year we were in a set of 'ring grazing' orbits, where Cassini came as close as possible to Saturn's rings, just outside the F Ring," says Linda Spilker, Cassini's project scientist.

During these flybys Cassini took some of its best images of the planet's rings and several moons. Twenty orbits later, the probe moved to a new trajectory, and on 26 April it performed one of its most daring feats – a dive between the planet and its rings.

▲ Cassini met its end after a 20-year mission, 13 of which it spent orbiting Saturn

Unsure if Cassini could survive the plunge, the team used the probe's antenna as a shield against potentially damaging ice particles. It quickly became apparent that any dust within the gap was too small to affect Cassini, allowing scientists to use the spacecraft's full set of instruments.

While previous observations had looked at the outside of the planet, these passes would allow them to look within Saturn, at its magnetic and gravitational profile. But as the team began to interpret their data, something was not quite as expected.

"We were looking at something called the gravitational coefficients, which tell us what Saturn's internal structure is like. As we got closer in those coefficients were so different to what we predicted that the internal structure of Saturn is not what we expected at all," says Spilker.

Not only that, but the planet's magnetic field was found to be aligned with Saturn's axis of rotation to within less than 0.06°.

"All our models need there to be a larger offset, because that drives the current flow in Saturn which maintains the magnetic field. Either the magnetic field is going to die out or there's something we don't understand shielding the real field from us," says Spilker.

These ring dives put forward a new set of questions for planetary scientists, but Cassini won't be on hand to help answer them. On 11 September, the spacecraft took its last gravitational nudge from Titan, sending it on a collision course with Saturn's atmosphere four days later. Even during this final descent, Cassini was still transmitting data back to Earth.

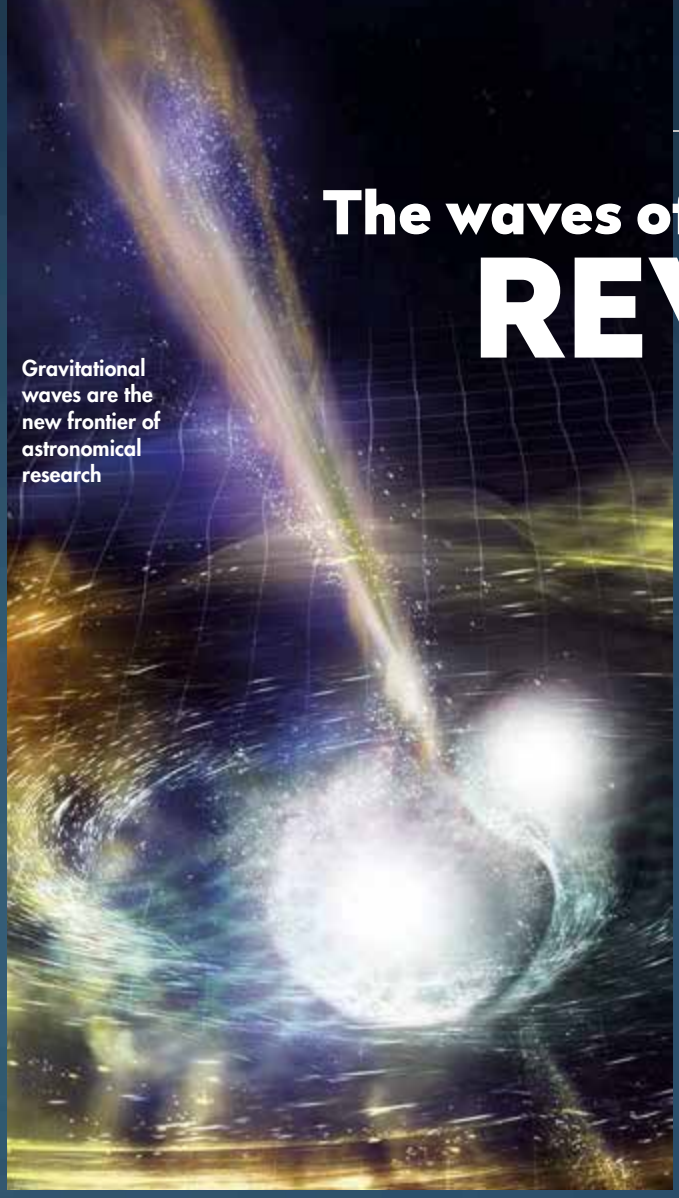
"We had a prediction for when the signal would drop off but it lasted about 30 seconds longer, probably because the atmosphere was a little bit less dense than we had estimated," says Spilker. "The spacecraft did everything we asked it to do."

At 07:55 EDT (12:55 UT) the Deep Space Network detected Cassini's final transmission. One minute after entering Saturn's atmosphere, the spacecraft broke apart and fell silent. But the scientific legacy of the mission is far from over. With years' worth of data to look at, Cassini will continue to help astronomers push the boundaries of planetary science for decades to come.

▲ Cassini's last look at cloudy Titan before its fatal plunge, captured on 13 September

▲ Cassini's final shot of Saturn shows its night side, where it would enter the atmosphere

NASA/JPL-CALTECH, KEVIN GILL/FLICKR, NASA/JPL-CALTECH/SPACE SCIENCE INSTITUTE X 2, NSF/LIGO/SONOMA STATE UNIVERSITY/A. SIMONNET, ILLUSTRATIONS BY PAUL WOOTTON



Gravitational waves are the new frontier of astronomical research

The waves of REVOLUTION

Einstein was right about gravitational waves, and now science can prove it

In the two years since the twin LIGO observatories in the US made the first detections, gravitational astronomy had been handicapped. With only two observatories, it was impossible to pin down the origin of waves to less than a few hundred square degrees of sky.

Gravitational astronomy is most powerful when used alongside electromagnetic observations – from radio through visible to X-ray and gamma. But finding these counterparts has been impossible given a search field so broad. And so on 1 August the Virgo interferometer near Pisa, Italy, joined LIGO in its search for the waves.

Fourteen days later, they made their first joint detection, a pair of stellar-mass black holes merging. With three points of reference, the source was narrowed down to a mere 60 square degrees of sky, but the event was simply too dim to be picked up by any other telescope. But on 17 August, LIGO detected a wave created by colliding neutron stars for the first time, an event which should be accompanied by a hugely bright kilonova explosion. With Virgo's help, the team narrowed the search area to 30 square degrees in the southern hemisphere. Dozens of the world's best scopes – ALMA, VLT, the Hubble Space Telescope and many others – searched the sky for any sign of the kilonova. Before the end of the night they found a new point of light in the galaxy NGC 4993, the first electromagnetic counterpart to a gravitational wave.

After decades of trying, astronomers had finally managed to not only detect a gravitational wave, but been able to watch its visual counterpart for days after. Though the kilonova has faded, its legacy has not. The gravitational revolution of astronomy has begun.

► **Read our interview with the astronomer who was the first to see the light from the graviational wave event on page 106**

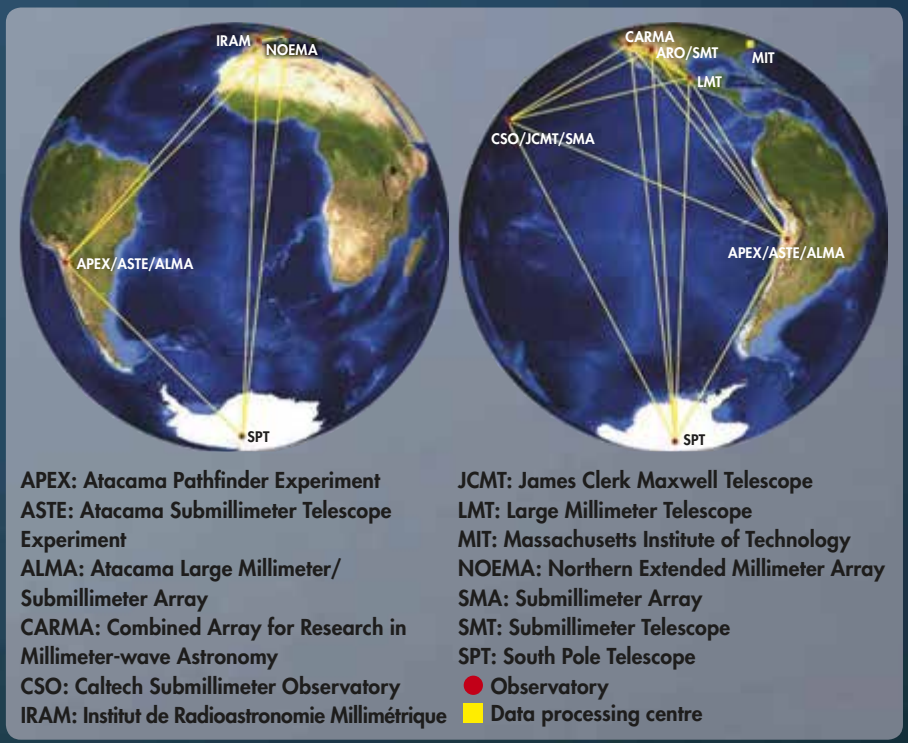
Age of the ARRAY

A thousand telescopes are better than one

As we look deeper into the Universe, astronomers are building bigger telescopes using dozens, hundreds or even thousands of dishes working together as one. And the benefits of these spread out scopes are beginning to show.

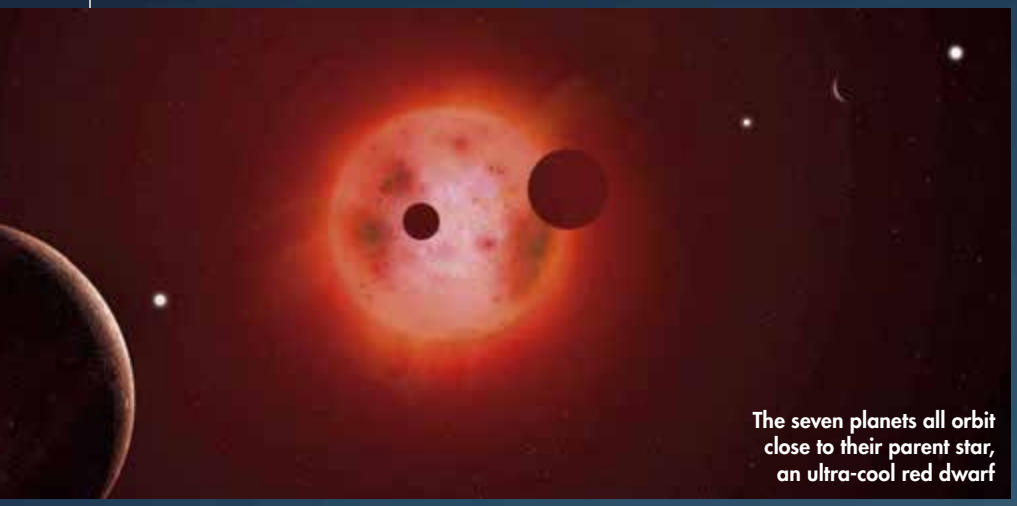
In April, eight independent telescopes joined together to create the Event Horizon Telescope. This planet-spanning instrument was aimed at the heart of the Milky Way, with the goal of imaging the black hole at its centre. But they still don't know if the attempt was a success. Processing the image was delayed until September, when the South Pole Telescope thawed out enough for the hard drives to be flown to the data centre at MIT.

One participating telescope was the Atacama Large Millimeter/Submillimeter Array (ALMA), and this was just a single example of the many great discoveries made with the array this year. In the past 12 months, its gaze has spanned the cosmos: from our Solar System – where it found vinyl cyanide, which could form cell-like membranes, on Titan – to the Universe's most distant reaches, observing oxygen in gas clouds as far back as 13 billion years ago.



APEX: Atacama Pathfinder Experiment
ASTE: Atacama Submillimeter Telescope Experiment
ALMA: Atacama Large Millimeter/Submillimeter Array
CARMA: Combined Array for Research in Millimeter-wave Astronomy
CSO: Caltech Submillimeter Observatory
IRAM: Institut de Radioastronomie Millimétrique
JCMT: James Clerk Maxwell Telescope
LMT: Large Millimeter Telescope
MIT: Massachusetts Institute of Technology
NOEMA: Northern Extended Millimeter Array
SMA: Submillimeter Array
SMT: Submillimeter Telescope
SPT: South Pole Telescope
● Observatory
■ Data processing centre

▲ The Event Horizon Telescope is a network of telescopes and arrays located across the globe



The seven planets all orbit close to their parent star, an ultra-cool red dwarf

▲ Despite their proximity to their star, several of the TRAPPIST worlds could possess liquid water

The seven worlds of TRAPPIST-1

All are Earth sized and some might have water

A new planetary system has dominated the field of exoplanetary science this year: TRAPPIST-1. In May, a team of astronomers announced they had found a system of seven Earth-sized planets in orbit around an ultra-cool red dwarf, designated TRAPPIST-1 after the small telescope in Chile that it was discovered with. The planets are all close to the star, with orbits lasting a matter of days, but the star's cool temperature means that some could still potentially hold liquid water on their surfaces.

The system was found during TRAPPIST's survey of 50 low-mass stars, a prototype search to test the idea that such stars could be home to observable planets. Smaller, dimmer stars are well suited to studying transiting planets because the signs of a planet aren't as swamped by the star's glare.

"We are already doing many follow up observations," says Michael Gillon from the Université de Liège, who led the TRAPPIST team. "Most notably we are trying to measure the masses of the planets."

The masses range between 0.2 and 1.6 times the mass of the Earth, and once these are pinned down precisely researchers will be able to measure their density. In turn, this will give them an idea of the planetary composition and what kind of atmosphere they might have.

"We are currently trying to look for atmospheres with Hubble but it can only find low-density atmospheres that are rich in hydrogen. But, if we can detect hydrogen, that's a strong indication that they have an atmosphere that is rich in water," says Gillon.

Though astronomers will likely have to wait until the next generation of telescopes are operational to really understand these planets, they are already trying to work out what they might be able to find.

"There was a study of the star itself," Gillon continues. "Its ultraviolet and X-ray emission isn't intense enough to have stripped the planets of their atmosphere and water completely, so they remain good habitable planet candidates." The emissions also show that the star, and so the planets, are between 5 to 10 billion years old, much older than the Earth's 4.5 billion years. Could life have evolved on these planets?

"The conditions are not Earth-like, it's not Earth Two. But at least a few of these planets could have liquid water. That, along with the energy from the star and the fact that organic molecules composed of hydrocarbons are quite common, means you could have the emergence of life on one of these planets," he says.

ESO/M. KORNMESSER, MARK GARLICK/ALAMY STOCK PHOTO, ISTOCK, CHUCK BIGGER/ALAMY STOCK PHOTO, SPACE X/FLICKR X 2, NASA, ESA-STEPHANE CORVAJA/2017, ESA/SCIENCEOFFICE.ORG

Totality during the US eclipse, the moment the Moon completely masked the Sun's disc

The Great American ECLIPSE

The most watched eclipse event in history

On 21 August, an eclipse crossed the US mainland from coast to coast for the first time in nearly a century. It's estimated that 215 million American adults viewed the eclipse either in person or digitally.

On the day NASA, schools, planetariums, museums and societies ran thousands of events to promote science and astronomy to this massive audience. However, many of these came close to being cancelled amid fears that thousands of the eclipse glasses which were sold or given away ahead of the event were not safe. Public health warnings circulated on the nation's news channels, while science enthusiasts fought to make sure the events went ahead.

Thankfully, most glasses were up to scratch and got put to good use on the day. After the event, the organisation Astronomers Without Borders called for people to donate their glasses so that they could be sent out to schools in Chile and Argentina, which will both experience a total solar eclipse in 2019 and again in 2020. The group want to bring the magic of totality to as many people as possible, without the risk of anyone losing their eyesight.

SpaceX has made 15 successful launches in 2017 so far

Spaceflight AMBITION

Humanity's aspirations to explore the Solar System have grown in 2017

Since 2001, the International Space Station has been humankind's only full-time foothold beyond the surface of the Earth. Staying on the permanent station has allowed astronaut Peggy Whitson to rack up an impressive 665 days in space, setting a new flight time record for a US astronaut. But the ISS might not be alone much longer. The Chinese National Space Administration (CNSA) has conducted several orbital docking and refuelling tests on its second temporary space station, Tiangong-2, throughout 2017. The station is intended as a testbed for technologies to create a future permanent Chinese space station. In August, two ESA astronauts Samantha Christoforetti and Matthias Maurer spent nine days with Chinese taikonauts, training for a water landing on return from such a station, boding well for potential European collaboration on the station.

SpaceX successfully landed its first reused Falcon 9 in March

However, CNSA's lunar ambitions hit a snag on 2 July, when one of their Long March 5 rockets failed. Another Long March 5 was meant to take the Chang'e 5 lunar sample return mission to the far side of the Moon this November, but has been postponed while the agency investigates the fault.

NASA and ESA's ambitions have met with complications too, as real-term funding cuts have caused the agencies to cancel the joint AIDA mission, intended to intercept and deflect an asteroid.

The year has been much more fortuitous for SpaceX. The company finally achieved one of its long term aims of reusing a rocket booster stage, and later one of its Dragon cargo modules. However, in October company founder Elon Musk announced SpaceX was abandoning its stalwart Falcon rockets to develop a completely reusable system, the BFR, which could take people to Mars as early as 2024.

▲ Peggy Whitson holds the US record for cumulative time in space – a huge 665 days

▲ Samantha Christoforetti during joint training with Chinese taikonauts this August

▲ The ambitious joint NASA/ESA asteroid mission AIDA fell victim to funding troubles

ABOUT THE WRITER

Dr Elizabeth Pearson is *BBC Sky at Night Magazine*'s news editor. She gained her PhD at Cardiff University

Orion flies high over Exmoor, home to one of only three International Dark Sky Reserves in the UK

Extraordinary EXMOOR

As an International Dark Sky Reserve, the wilds of Exmoor are a wonderful place to turn your eye to the sky. **Will Gater** gives us a tour

On the northern coast of the West Country, where the rolling hills of West Somerset and North Devon meet, lies Exmoor National Park. A landscape that comprises everything from spectacular cliffs rising up out of the English Channel, to great tracts of windswept moorland and wooded valleys, Exmoor has long been a favourite place for those who love the outdoors and an adventure among picturesque surroundings. But now it's also becoming famous for the splendour of its night-time skies. The heart of the moor is home to one of the few truly dark-sky areas in the UK, which is why, in 2011, a section of it was designated an International Dark Sky Reserve by the International Dark Sky Association.

To see why Exmoor has attracted the attention of astronomers one only needs to stand under a clear night sky in the core of the reserve. In the summer months the Milky Way is a magnificent sight, its rich star fields easily visible to the naked eye, with an obvious multitude of dark dust lanes winding through the glowing patches of light. In late winter and early spring the phenomenon of the zodiacal light is an easy spot with direct vision too, after the Sun has set. And as for astrophotography, the inky skies offer the chance to push the boundaries of what can be captured, being free from the strong gradients and skyglow associated with imaging the heavens from suburbia.

Searching for the best spots

Out on the moor, a handful of observing sites have been recommended after considering a wide range of requirements, says Dan James of the Exmoor National Park Authority: "As part of the International Dark Sky Reserve application we'd taken light readings at numerous points across the moor, so we knew which were our really dark spots. But sometimes the darkest areas aren't necessarily the best places to be sending novices ▸

From Exmoor even the zodiacal light can be seen with the naked eye

WILL GATER X 2

▸ at night because they tend to be extremely remote, extremely wild places," he says. "So selecting a site meant taking on board the darkness of the sites, but also thinking a bit more practically about where can they pull off the road sensibly and safely; where is there a flat surface; where have they got an unobstructed view of the horizon."

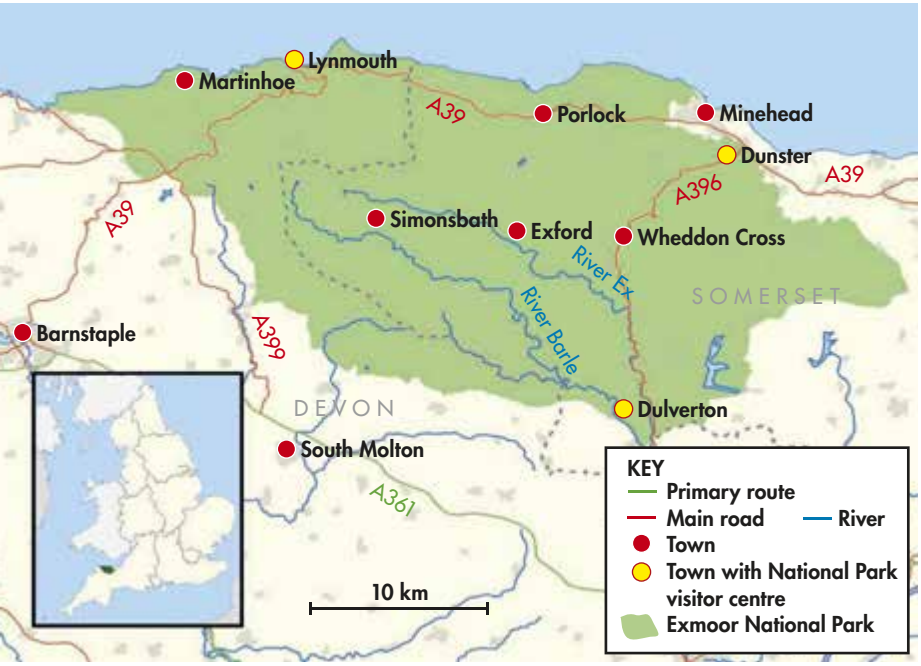
It's fairly straightforward to get to Exmoor by car. If you're travelling from further up the country you'll want to leave the M5 at Taunton (Junction 25) and head in the direction of Bishop's Lydeard. From there you can take the B3224 towards Wheddon Cross which will take you right into the heart of the national park and the region's dark skies. If you have the time and are arriving in daylight, you can take a longer, but picturesque, coastal detour into the park via the A358 and A39. Similarly the drive into Exmoor from Junction 27 of the M5, via Tiverton and the A396, and you'll find yourself winding through some of the West Country's most beautiful wooded valleys; this route is also ideal if you want to stop into the town of Dulverton, on the edge of the moor, to pick up supplies.

At Dulverton, as well as in Dunster and Lynmouth in the northeast and northwest of the park, you'll also find an Exmoor National Park visitor centre too. These centres have plenty of information about local attractions, hiking routes and wildlife, and – most importantly for astronomers – a leaflet that contains a map of the International Dark Sky Reserve and the suggested observing sites.

▲ The images taken under the pristine conditions found in parts of Exmoor can be fantastic. Here we see the North America Nebula and its surroundings [1], the Lagoon and Trifid Nebulae with a globular cluster [2], and the Scutum Star Cloud [3]

EXPLORING EXMOOR

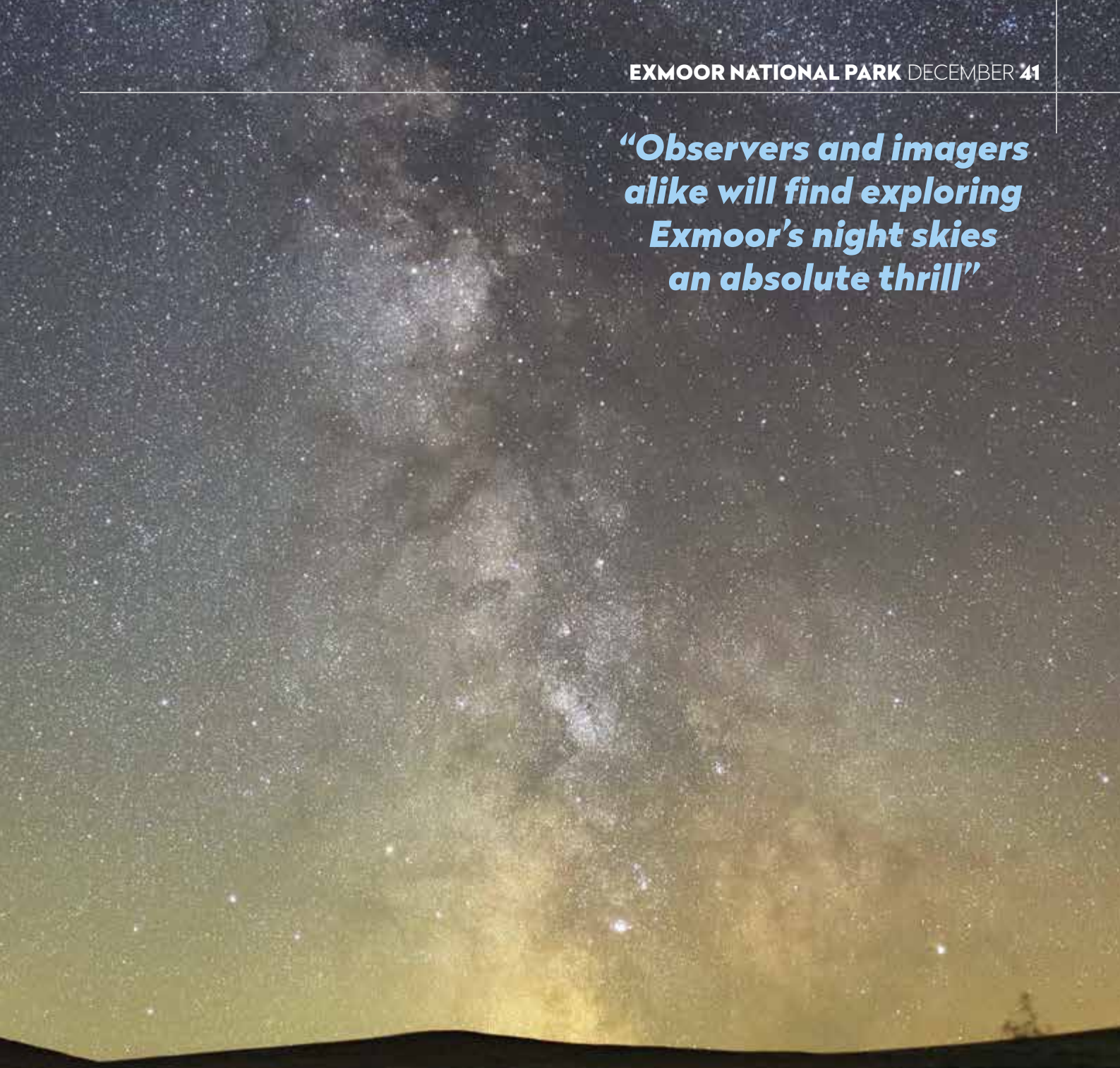
The best places to base yourself during an escape to the open moors



Homing in on the darkness

If you're planning to stay in or around Exmoor for an extended stargazing break, there are plenty of hotels, guest houses and B&Bs to choose from. If you want to be really close to the very best dark skies Exmoor has to offer then you should aim to find accommodation close to Exford, Simonsbath or Wheddon Cross; from there you'll be able to drive out onto the open moorland roads in just a few minutes. But even if you choose to stay on the coast, at Lynmouth or Porlock for example, you'll only be a 15-minute drive from the darkest skies in the National Park.

Like many rural areas Exmoor has plenty of narrow, winding lanes – some very steep – so it's



"Observers and imagers alike will find exploring Exmoor's night skies an absolute thrill"

helpful if you are comfortable driving on and navigating this type of road at night.

The hills of Exmoor are generally very exposed too and, at night in winter especially, it can get bitterly cold at many of the best observing sites; warm clothing, sturdy shoes and a warm drink and some snacks are therefore essential on any Exmoor stargazing trip.

For astrophotographers the exposed moorland hills also present another challenge, in the form of breezes and wind that can vibrate an imaging setup and frustrate any autoguiding system you may be using. If you're planning on doing longer focal length, high-resolution astrophotography from Exmoor, it's particularly advisable to find a sheltered imaging location. For wide-field work wind vibration is slightly less of an issue, but is always something to bear in mind as a possibility and plan for accordingly; for example, if you have the option, you may want to bring a regular tracking mount with you rather than a lightweight, portable one, as it is likely to be heavier and therefore sturdier.

▲ The Milky Way from Exmoor is simply magnificent, with the dark dust lanes that scythe though this pale river easy to see

Although Exmoor's night skies are generally wonderfully dark, there are a small number of light domes visible from within the National Park. The southern half of the sky has the darkest skies with only a few small light domes low on the horizon – most likely to come from distant towns in Devon – while the northern horizon is affected quite noticeably by the light pollution from South Wales.

By and large, though, observers and imagers alike will find exploring Exmoor's night skies an absolute thrill. Binocular observing, for example, is a delight under the dark skies there. In the summer, especially, hours can be lost scanning the numerous bright nebulae and open star ▸

WILL GATER X 4; EXMOOR MAP: CONTAINS ORDNANCE SURVEY DATA © CROWN COPYRIGHT AND DATABASE RIGHT

▸ clusters in and around Sagittarius, Scutum and Serpens. And if you have a telescope with you, bright objects like the Orion Nebula (in winter) and the Lagoon Nebula (in summer) become truly breathtaking sights that just jump out against the inky black. You needn't worry if you don't have a telescope to bring with you either. At some of the park's visitor centres it's possible to hire a small Dobsonian telescope.

If you do get out onto the moor to observe or image don't be surprised to find other stargazers and astrophotographers there – even in relatively remote spots; the increase in interest in Exmoor's dark skies in recent years has been dramatic.

ABOUT THE WRITER
Will Gater is an astronomy journalist, author and presenter. Follow him on Twitter at @willgater or visit willgater.com

"Until we started this journey there wasn't a lot of talk about the dark skies, whereas now it's almost weekly," says James. "It's on people's minds and we're now much more proactive at thinking 'okay, how can we not only protect these dark skies, but also encourage other people to enjoy them'."

With talk of Exmoor potentially getting an observatory in the future too, there could be yet more astronomers making tracks for the moor to see what all the fuss is about. Perhaps, one day, you'll be one of them.

FIND OUT MORE
Read an extended interview with Dan James at **www.skyatnightmagazine.com/news/dan-james**

▲ On a clear day the summit of Dunkery Beacon grants spectacular views of the moors

▲ Quaint Porlock is towards the coast, nestled between Dunster and Lynmouth

▲ Landacre Bridge and the River Barle, a charming spot to while away a few hours

MORE THAN JUST DARK SKIES

Sunrise reveals Exmoor to be an expansive realm of natural beauty and creature comforts

While many astronomers flock to Exmoor for its dark night skies, there's plenty to see and experience across this beautiful region during the daytime too. If hiking is your thing then there are numerous walking routes that will take you through some of the national park's most picturesque scenery. The walk to the top of Dunkery Beacon, for example, is well worth it, and on a clear summer's day you'll be rewarded with incredible views over the surrounding moorland and, on the horizon, the hills of Dartmoor in Devon. The north coast is not to be missed either, especially around Lynmouth and Martinhoe where the coastal path affords breathtaking views of the cliffs and Bristol Channel below. Farther along the coast to the east you'll find the delightful town of Porlock; the views of the surrounding countryside from the hills to the west of the town are particularly impressive.

If visiting the northeastern corner of Exmoor, Dunster is a wonderful place to spend a day exploring, especially if it's sunny. As well as a large castle, this beautiful village has a small Exmoor National Park visitor centre and a selection of boutique shops as well as several pubs and tearooms where you can sit back, relax and watch the world go by.

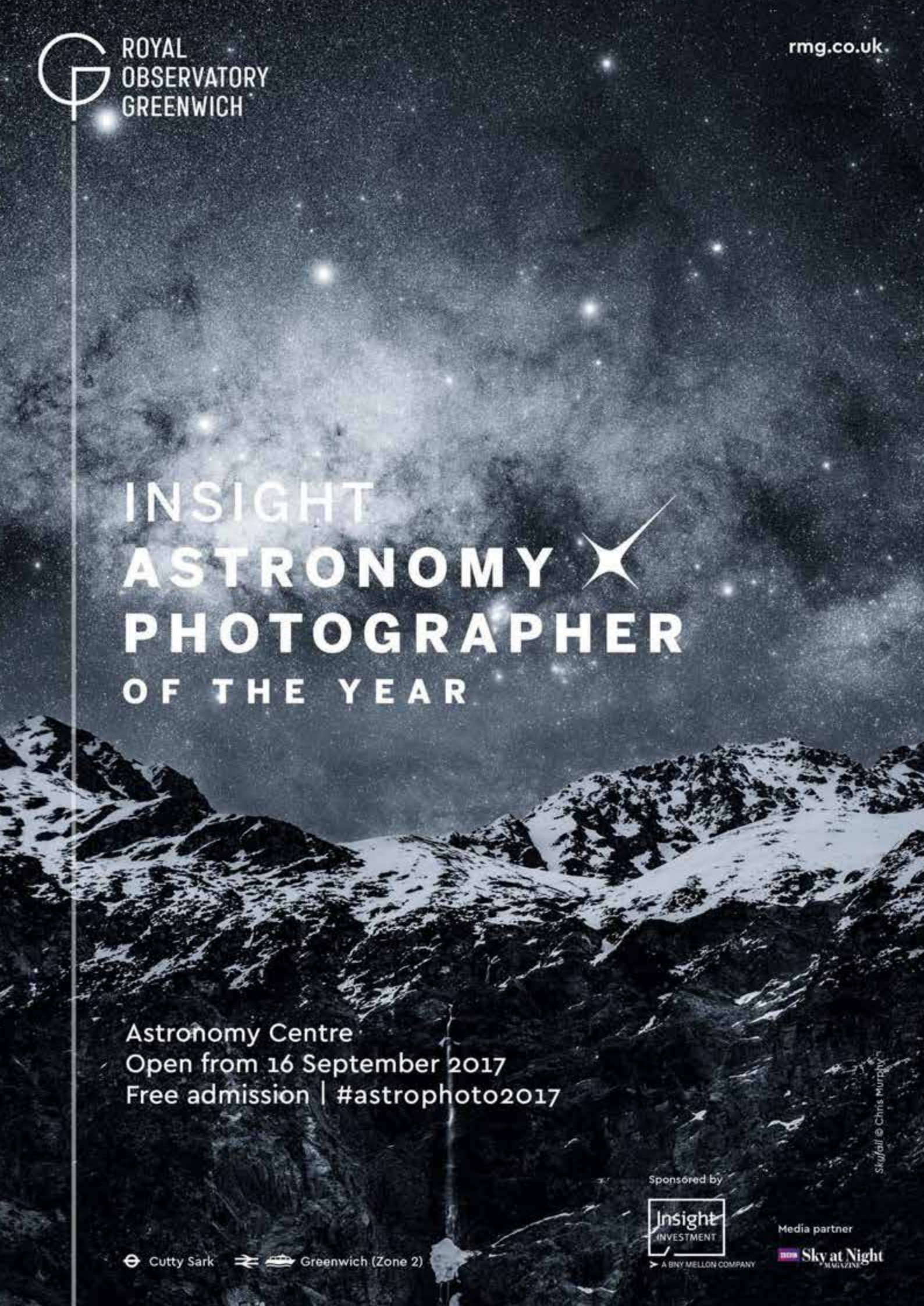
On the southern edge of the national park, the town of Dulverton is another place that should be on the itinerary of every Exmoor explorer. On a sunny day you can sit by the scenic River Barle and watch minnows in the crystal-clear shallows and dippers darting from rock to rock. There's an Exmoor National Park visitor centre, and for any little stargazers travelling with you there's also a large play park a short walk over the bridge from town. You'll also find a good range of places to eat as well as some charming shops and art galleries.

Finally, if the weather is warm, two fine places to stop for a moment on the moor are Withypool and nearby Landacre Bridge. These spots can get quite busy in the summer but are great places for riverside relaxation.

ROYAL OBSERVATORY GREENWICH

rmg.co.uk

INSIGHT ASTRONOMY PHOTOGRAPHER OF THE YEAR



Astronomy Centre
Open from 16 September 2017
Free admission | #astrophoto2017

Skyfall © Chris Murray

Sponsored by

Insight INVESTMENT
A BNY MELLON COMPANY

Media partner

BBC Sky at Night MAGAZINE

Cutty Sark Greenwich (Zone 2)

ARTHUR'S ODYSSEY

Celebrating the centenary of the birth of sci-fi writer Arthur C Clarke, **Nick Spall** looks at how the Space Age prophet's writings helped shape mid-20th century thinking

Few science-fiction writers have had such a powerful impact on space matters as Arthur C Clarke. From conceiving geostationary comsats in a 1945 article in *Wireless World* magazine to providing uncanny prophesies in his novels and non-fiction books, Clarke combined scientific accuracy with an extraordinary imagination for future worlds and advanced technology.

He followed in the footsteps of HG Wells, Olaf Stapledon and Konstantin Tsiolkovski, using strong science as the foundation of his speculation. He was a trained physicist and mathematician who had cut his teeth working on early radar and ground-controlled approach technology while serving in the RAF during World War II.

In the early 1930s, Clarke had been one of the founding 'space cadets' of the British Interplanetary Society. This group of enthusiasts suggested that orbital satellites, crewed space stations, Moon landings and interplanetary flight would soon be possible. When powerful German V2 rockets began raining down on London from heights of over 100km in 1944, spaceflight suddenly became more of a reality and the society was taken seriously.

Clarke had a deep belief that humanity was destined to be a spacefaring species. He was strongly impressed by reading Olaf Stapledon's prophetic book *Last and First Men* in 1930.

▲ Clarke's *Exploration of Space* is said to have been an inspiration for the Apollo programme

Following the story of early hominid development uncovered by paleoanthropologists like Louis Leakey, Clarke used his interest in human evolution and transcendence as the basis for many of his successful novels, including *Earthlight*, *The City and the Stars* and *Childhood's End*. For many, his ultimate story was *2001: A Space Odyssey*.

Ongoing odyssey

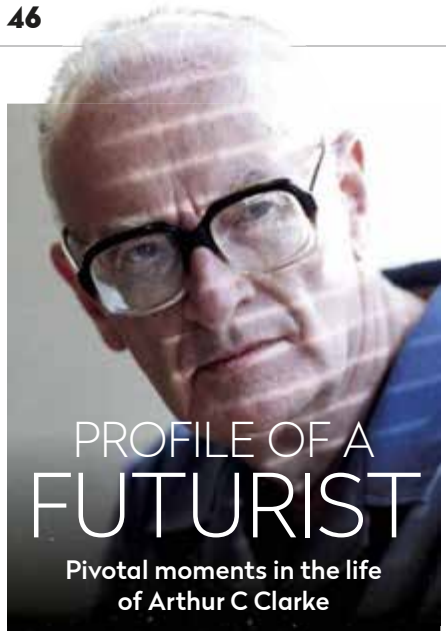
It was in *2001*, developed as a movie with director Stanley Kubrick and published as a novel after its release, that Clarke revealed his fascination with deep mysteries, including metaphysical ideas and the strange world of quantum physics and cosmology. The subsequent stories *2010*, *2061* and *3001* included ghost appearances, telekinesis and telepathy, though all within a scientifically reasonable framework.

Clarke's technical work focussed on opening up minds to the practical benefits of space exploration and the search for new worlds, both in the Solar System and beyond. His prophetic book *The Exploration of Space* (1951) is reported to have been shown by NASA's Wernher von Braun to US President John F Kennedy in 1962, helping inspire the US Apollo programme commitment to go to the Moon and back within the decade.

Clarke continually came up with new space exploration ideas, many of which are ▸

EVERETT COLLECTION INC/ALAMY STOCK PHOTO

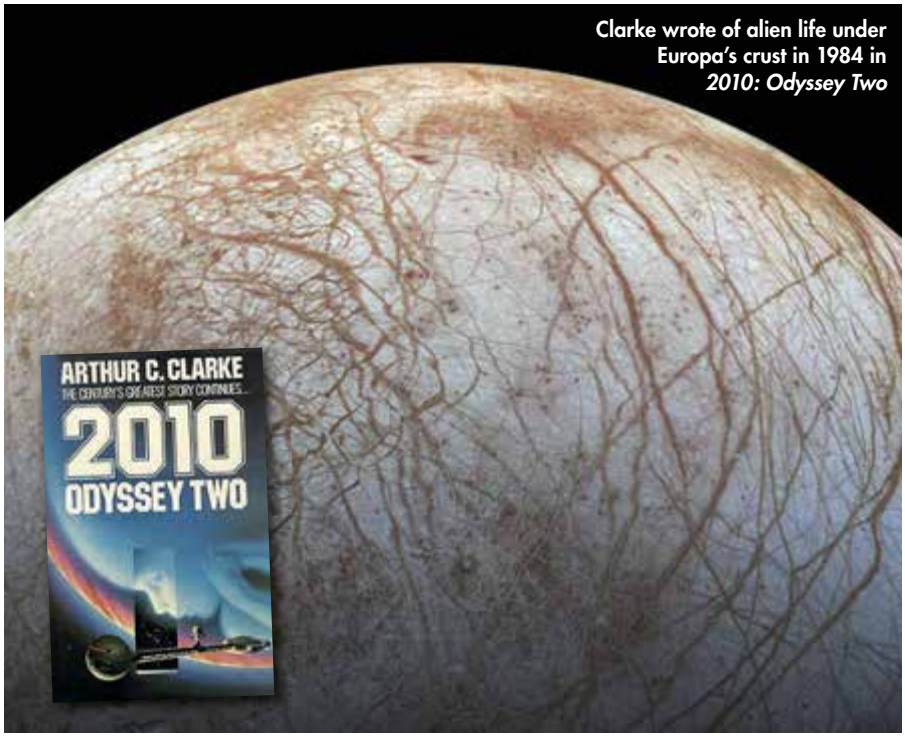
Arthur C Clarke on the film set of his magnum opus, *2001: A Space Odyssey*



PROFILE OF A FUTURIST

Pivotal moments in the life of Arthur C Clarke

- **16 December 1917** Born in Minehead, Somerset
- **Late 1920s** Develops a fascination with astronomy, telescopes, dinosaurs and mysteries
- **Late 1920s/early 1930s** Reads *Amazing Stories* and *Astounding Science Fiction* magazines
- **1934** Joins the British Interplanetary Society
- **1941-46** Conducts radar and ground-controlled approach work in the Royal Air Force
- **1945** Proposes geostationary satellite communications in *Wireless World* magazine
- **1948** Graduates with a BSc in mathematics and physics from King's College London
- **1950s** Devotes himself to full-time writing
- **1956** Moves to Sri Lanka, where he lives until the end of his life
- **1965-68** Works with Stanley Kubrick on *2001: A Space Odyssey*
- **1969-72** Becomes commentator for US TV channel CBS during the Apollo missions
- **1980** First episode of *Arthur C Clarke's Mysterious World* broadcast on ITV
- **1988** Diagnosed with post-polio syndrome, and is eventually confined to a wheelchair
- **2000** Receives a knighthood during a private ceremony at his home in Colombo, Sri Lanka
- **2007** Releases a video message on YouTube on his 90th birthday
- **19 March 2008** Dies and is later buried in Colombo



Clarke wrote of alien life under Europa's crust in 1984 in *2010: Odyssey Two*

▸ being genuinely considered today: terraforming another planet in *The Sands of Mars* (1951), space tourism in *A Fall of Moondust* (1961), interstellar world ships in *Rendezvous with Rama* (1973), space elevators in *The Fountains of Paradise* (1979) and near-Earth object protection in *Hammer of God* (1993). His sci-fi work inspired many of the big names in space exploration and science fiction, people like Carl Sagan, James Cameron and Buzz Aldrin.

Ample optimism

Clarke's technology forecasts also extended to earthbound matters. As part of the hi-tech futurist movement of the 1960s, Clarke always emphasised the benefits of science and technology, including artificial intelligence, famously portrayed by the paranoid spaceship computer HAL in *2001*; human cloning; the world wide web, thought to be inspired by his short story *Dial F for Frankenstein* (1961); personal computers; and even 3D printing, which he predicted as a 'replicator' in his 1962 book *Profiles of the Future*.

▲ Clarke was an early proponent of the idea that Halley's Comet could carry life

Clarke firmly believed in the probability of life existing elsewhere in the cosmos. His early writings speculated about primitive alien life on Mars. In later years he also focussed on the icy moon Europa as being the possible location of basic life forms in oceans beneath its ice crust, as described vividly in the novel *2010*. He followed the exobiology 'panspermia' research of Fred Hoyle and Chandra Wickramasinghe and projected the idea that Halley's Comet might have basic life forms in its icy dust surface.

While he deeply yearned for results in the search for extraterrestrial intelligence and believed in the probability of biology throwing up life across the Universe wherever it had the chance, Clarke appreciated the JBS Haldane thought that perhaps "the Universe is queerer than we can suppose".

Speculating on the possibilities of never finding intelligent extraterrestrial life across the Galaxy, Clarke famously quipped: "Two possibilities exist: either we are alone in the Universe or we are not. Both are equally terrifying". Indeed, Clarke was very fond of one-line quotes. His

EVERETT COLLECTION INC/ALAMY STOCK PHOTO, ISTOCK X 7, NASA X 4, PHOTO 12/ALAMY STOCK PHOTO

▲ The iconic scene in *2001* of Gary Lockwood running around the space station was unintentionally re-enacted by NASA Skylab astronauts

famous 'three Laws' included the powerful: "Any sufficiently advanced technology is indistinguishable from magic". The magic of the future fired his imagination to speculate and wonder at the Universe that was slowly being uncovered by space exploration.

Life imitates art

Clarke liked nothing better than to see the uncanny happen, including Apollo 13 astronaut Jack Swigert's now famous line "we've had a problem" having been previously spoken almost identically by his fictional HAL computer in the book *2001*. Ironically Apollo 13's orbiter was also called Odyssey. Seeing the NASA Skylab 2 astronauts running around the central ring interior of their station made him subsequently recall that he had already imagined that and, indeed, Kubrick had included it as part of the spacecraft in the *2001* movie.

> ***"Clarke was always optimistic about human progress. He believed that war and intolerance could be removed and technology could solve most Earthly problems"***

Clarke was always optimistic about human progress. He believed that war and intolerance could be removed and technology could solve most Earthly problems. Human destiny, he was convinced, was in space. "I have often thought, especially when scuba diving, that we don't really belong here on land, dragged down by gravity every moment of our lives – our future belongs to space," he said.

All who knew Clarke well recognised what a genuinely positive and rounded person he was. His grave epitaph seemed to say it all: "He never grew up, but he never stopped growing". As a space seer, Clarke has yet to be rivalled. S

ABOUT THE WRITER
Nick Spall is a freelance space writer. He's interviewed astronauts and experienced zero-G and parabolic flights

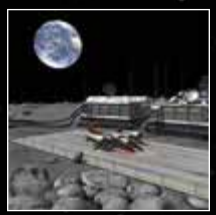
FORECASTING THE FUTURE

Though many of Arthur C Clarke's visionary ideas have come to fruition, there are plenty still to be realised

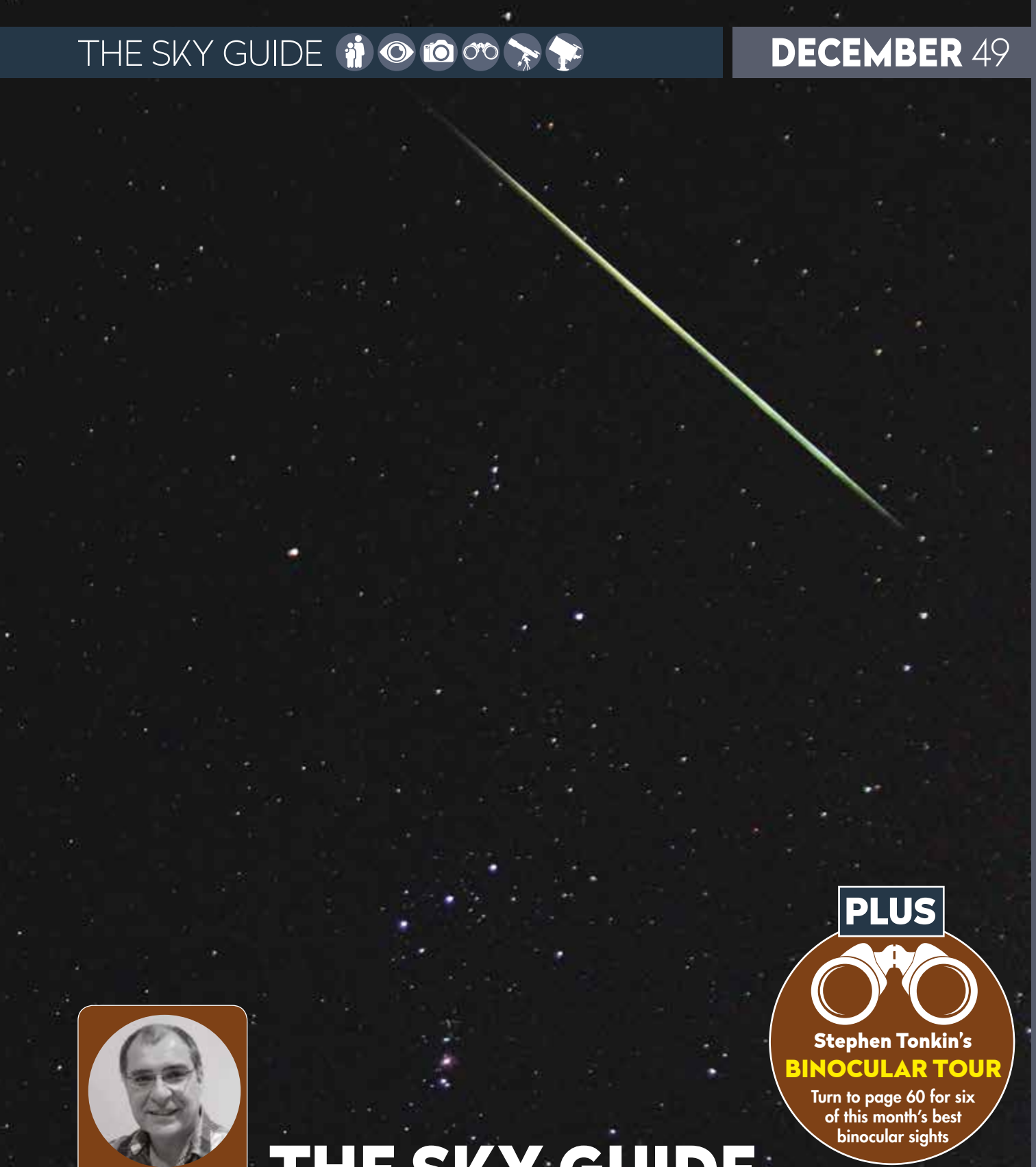
Already happened

- Geostationary comsats
- The world wide web
- Online banking and shopping
- Artificial intelligence
- Personal computers & smartphones
- Space tourism
- Space shuttles
- Space stations
- 3D printing
- Near-Earth object protection

Yet to come



- Moon bases
- Asteroid mining
- Extraterrestrial life discovered on Europa and comets
- Cold fusion
- Terraforming Mars and exoplanets
- Space elevators
- 'Braincap' recording of thoughts and dreams
- Gravity control
- Inertial 'space-drive' propulsion
- Contact with alien intelligence



PETE LAWRENCE

PLUS

Stephen Tonkin's
BINOCULAR TOUR

Turn to page 60 for six of this month's best binocular sights

WRITTEN BY
PETE LAWRENCE

Pete Lawrence is an expert astronomer and astrophotographer with a particular interest in digital imaging. As well as writing *The Sky Guide*, he appears on *The Sky at Night* each month on BBC Four.

THE SKY GUIDE
DECEMBER

The annual Geminid shower is a highlight of the meteor calendar. The long, dark December nights offer a perfect backdrop, with only the weather and the Moon able to spoil the show. We can't predict the weather but, this year at least, the Moon will stay largely out of the way.

DECEMBER **HIGHLIGHTS**

Your guide to the night sky this month

◀ SUNDAY 3

Tonight's full Moon occurs when the Moon is close to perigee, the point in its orbit when it is closest to our planet.

WEDNESDAY 6

Look for Jupiter through a telescope around 06:30 UT this morning and you will be able to see its outermost Galilean moon, Callisto, passing close to its southern limb.

THURSDAY 14

Mag. –1.6 Jupiter, mag. +1.6 Mars and a 13%-lit waning crescent Moon form a triangle this morning. Look low in the southeast.

Asteroid 3200 Phaethon appears to be emerging from the southwest boundary of open cluster M34 in Perseus this evening.

FRIDAY 15

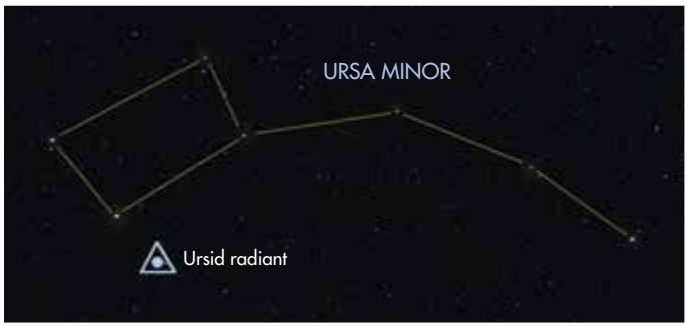
Look at Jupiter through a scope around 06:30 UT and you will see a tight triangle of Galilean moons to the west of Jupiter's disc – Europa, Ganymede and Callisto. The remaining moon, Io, can be seen to the east.

MONDAY 18

The Moon is new and, incidentally, close to apogee, the farthest point in its orbit from Earth. This means that the skies are very dark and perfect for taking our Deep-Sky Tour on page 62. This month we're looking at some of the wonderful objects in Auriga.

WEDNESDAY ▶ 20

With the Moon out of the way and the Sun close to its most southerly point in the sky, the nights don't get darker than this from the UK. This is a perfect time to enjoy the beautiful sights in and around Orion, which is prominently on display due south around midnight.



◀ FRIDAY 22

Tonight is the peak of the annual Ursid meteor shower. Like this year's Geminids, the Moon is also favourably placed for the Ursids. The shower has a peak zenithal hourly rate of 10 meteors per hour, but has been known to go as high as 50 in the past.

SATURDAY 23

There's another chance to catch the outermost Galilean moon, Callisto, passing close to Jupiter's southern limb this morning. Jupiter also appears 42 arcminutes from the mag. +2.9 double star Zubenelgenubi (Alpha (α) Librae). View from 05:00 UT.

FAMILY STARGAZING – 3 DEC

The full Moon on 3 December will arc high across the night sky and appear very prominent. An interesting exercise for budding young observers is to provide them with paper and pens and get them to draw as much detail as they can see on the Moon's disc. Explain that the dark patches are called seas, but contain no water, instead being areas of dark, solidified lava. Once the drawing is complete, put the date and time on it and store it safely away. Repeat the exercise again in the future to see how well their observing and recording skills have progressed. www.bbc.co.uk/cbeebies/shows/stargazing

PETE LAWRENCE X 8

WEDNESDAY 27

Tonight's 65%-lit waxing gibbous Moon shows a favourable libration for the northern limb.

SATURDAY 30

Tonight's 91%-lit waxing gibbous Moon appears to be moving in front of the Hyades open cluster in Taurus, occulting some of the cluster stars as it goes.

WEDNESDAY ▶ 13

The annual Geminid meteor shower peaks tonight. Turn to page 52 for details of how to observe this exciting event and page 59 for details of how to find asteroid 3200 Phaethon, the body responsible for producing Geminid meteors.

◀ SATURDAY 16

Asteroid 3200 Phaethon is undergoing a close approach of Earth, with a minimum distance of 10.25 million km. The mag. +10.7 asteroid is 2.5° to the east of mag. +2.1 Mirach (Beta (β) Andromedae) in the early part of the evening.

SUNDAY 17

Asteroid 3200 Phaethon will be within the Great Square of Pegasus from the time the sky darkens until it sets at around 01:30 UT. It is expected to have faded slightly after yesterday's close approach to around mag. +11.6.

THURSDAY ▶ 21

The Sun reaches its most southerly declination today, passing a point in time known as the northern hemisphere's winter solstice. After today, the nights will start getting very slightly shorter.

SUNDAY 24

Jupiter is just 4 arcminutes from mag. +7.7 HIP 72769 in the morning sky – the star appearing like an extra moon.

MONDAY ▶ 25

The lunar lighting effect known as the lunar X can be seen forming as the Moon rises above the eastern horizon. Despite being daylight, the effect should be visible when the Moon peaks around 13:40 UT, a perfect Christmas Day treat.

◀ SUNDAY 31

The lunar occultation of the Hyades reaches its peak this morning. The 93%-lit waxing gibbous Moon occults mag. +0.9 Aldebaran (Alpha (α) Tauri) around 01:06 UT, reappearing from behind the Moon's illuminated edge at 01:54 UT. Times are for the centre of the UK and will vary with location.

NEED TO KNOW

The terms and symbols used in *The Sky Guide*

UNIVERSAL TIME (UT) AND BRITISH SUMMER TIME (BST)
Universal Time (UT) is the standard time used by astronomers around the world. British Summer Time (BST) is one hour ahead of UT.

RA (RIGHT ASCENSION) AND DEC. (DECLINATION)
These coordinates are the night sky's equivalent of longitude and latitude, describing where an object is on the celestial 'globe'.

FAMILY FRIENDLY
Objects marked with this icon are perfect for showing to children

NAKED EYE
Allow 20 minutes for your eyes to become dark-adapted

PHOTO OPPORTUNITY
Use a CCD, planetary camera or standard DSLR

BINOCULARS
10x50 recommended

SMALL/ MEDIUM SCOPE
Reflector/SCT under 6 inches, refractor under 4 inches

LARGE SCOPE
Reflector/SCT over 6 inches, refractor over 4 inches

GETTING STARTED IN ASTRONOMY

If you're new to astronomy, you'll find two essential reads on our website. Visit http://bit.ly/10_Lessons for our 10-step guide to getting started and http://bit.ly/First_Tel for advice on choosing a scope.

THE BIG THREE

The three top sights to observe or image this month

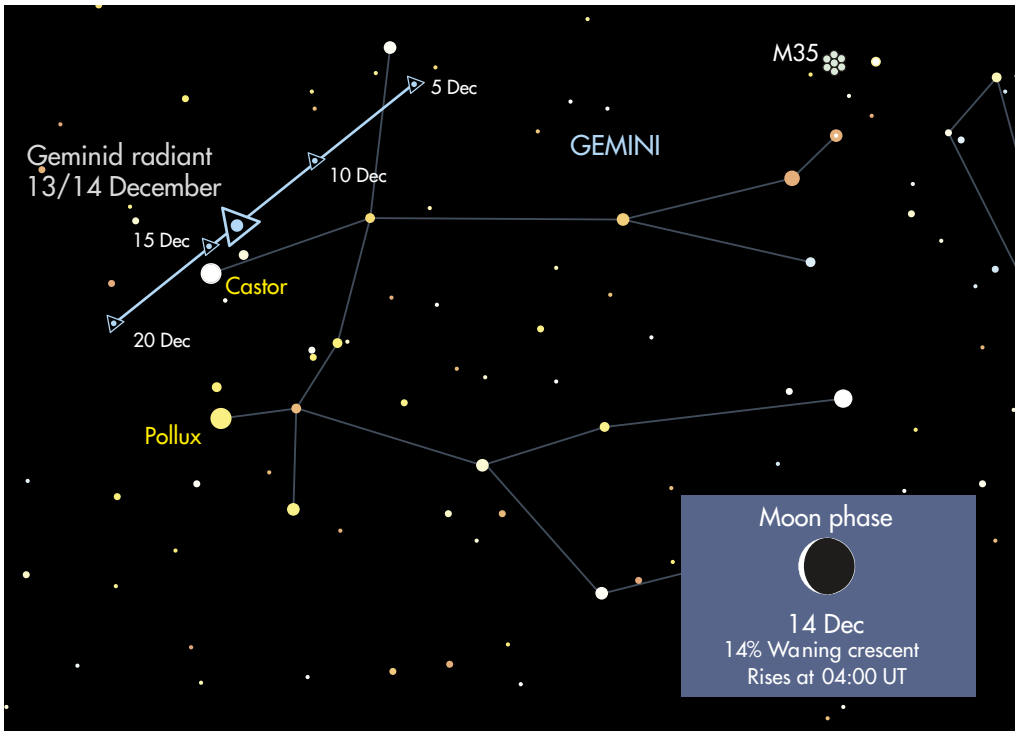
DON'T MISS

Ursids and GEMINIDS

WHEN: Nights of 12-15 December for the Geminids, 22/23 December for the Ursids

The Geminid meteor shower reaches peak activity on the night of 13/14 December. Assuming the weather is kind, on the night of the peak, the Moon will appear as a 14%-lit waning crescent, rising above the east-southeast horizon around 04:00 UT on 14 December. Astronomical twilight begins around 05:20 UT, marking the end of true darkness. Consequently, even when it has climbed appreciably above the horizon, that slender crescent Moon is not going to interfere much at all.

The Geminids have a zenithal hourly rate (ZHR) of around 120 meteors per hour. This is a normalised rate used to assess true activity. The visual rate varies according to conditions, but it's realistic to expect between 35-55 meteors per hour under skies with a limiting magnitude of +6.0 to +6.5. For less perfect skies with a limiting magnitude of +5.0 to +5.5, the expected visual rate drop to around 14-22 meteors per hour. It pays to get somewhere as dark as possible for the best show.



▲ Geminid trails should lead back towards the shower radiant, close to Castor at the peak

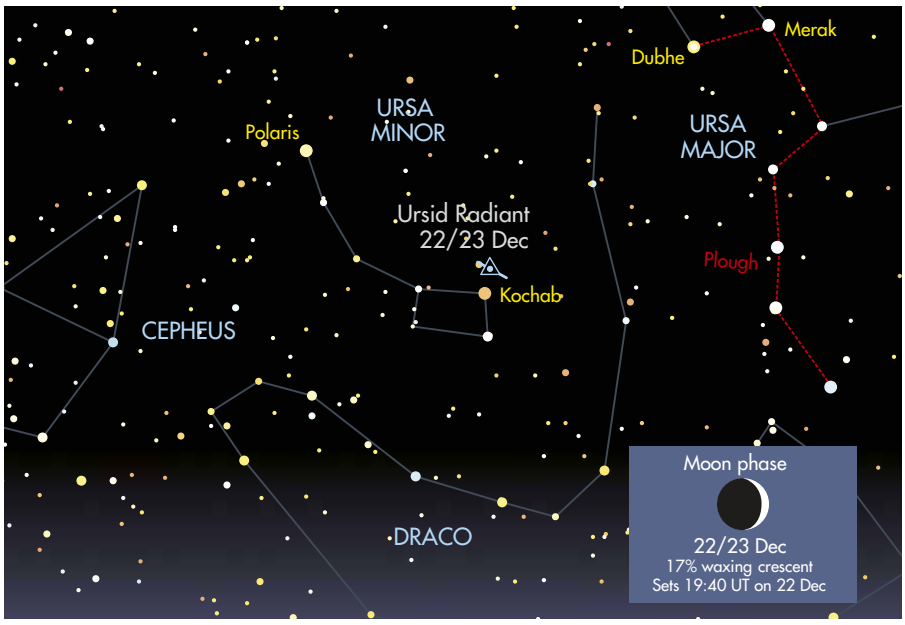
The shower is expected to peak at 06:30 UT on the morning of 14 December but in contrast to the sharp Perseid peak in August which lasts just a few hours, the Geminid peak is broad, lasting for around a day.

A day ahead of the peak, the shower tends to show a good number of faint meteors. Don't be fooled though, because this is just a taster for the main event. A clear peak night display of the Geminids can be pretty spectacular, often with many bright events streaking across the winter sky. The meteoroids that cause the shower have an entry speed of 35km/h, making makes them ideal photographic targets.

The Geminids are active from 4-17 December. For a trail to qualify as a Geminid it must appear to come from the shower radiant; the chart above shows where this is located. If a meteor isn't coming from the radiant, it isn't a Geminid.

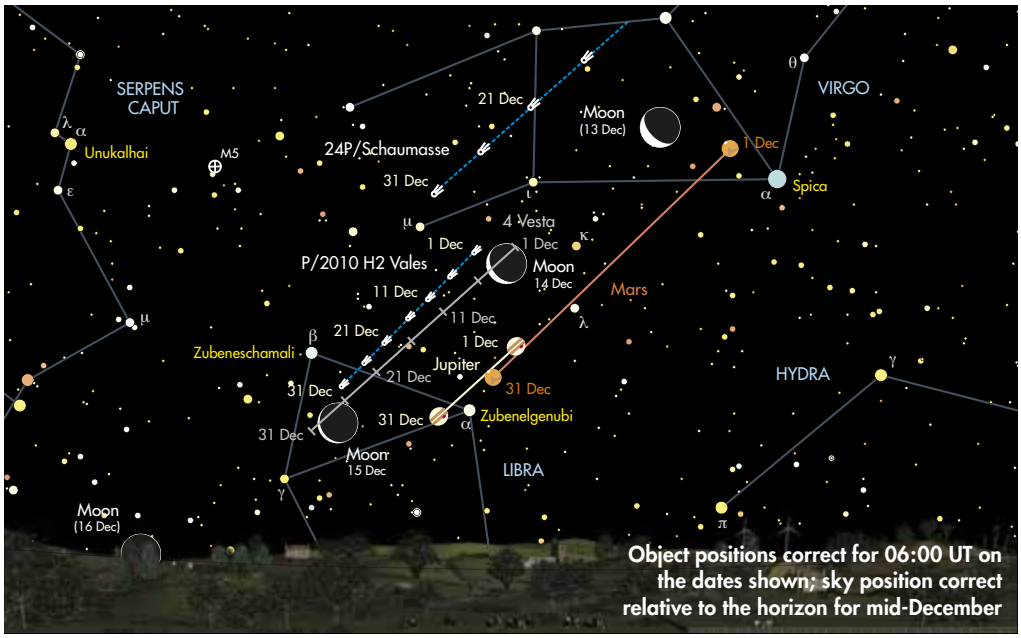
Geminids appear when Earth passes through debris distributed around the orbit of asteroid 3200 Phaethon. This month we get a rare chance to see Phaethon as well, as it passes relatively close to Earth. Check page 59 for further information on how to see it through a small telescope.

The Ursid meteor shower continues directly after the Geminids, with activity from 17-26 December. The ZHR for this shower is much lower, at just 10 meteors per hour, but again the Moon will be out of the way, leading to excellent dark skies. Peak activity occurs on the night of 22/23 December from a radiant position close to mag. +2.1 Kochab (Beta (β) Ursae Minoris).



▲ The Ursid radiant is close to bright star Kochab, at the opposite end of Ursa Minor to Polaris

PETE LAWRENCE X 4



Object positions correct for 06:00 UT on the dates shown; sky position correct relative to the horizon for mid-December

A busy morning sky

WHEN: From 13 December onwards

There's an interesting gathering in the early morning sky of two bright planets, the Moon, an asteroid and two comets. The planets in question are Jupiter and Mars, both of which can be seen in the pre-dawn sky from the start of December onwards, and the asteroid is Vesta. It's moving on a path to the north of Jupiter and remains at 8th magnitude all month, so you'll need at least a pair of binoculars to see it. The asteroid is best positioned from the middle of the month onwards, when it will have crept away from the morning twilight and can be seen against the darkest skies.

Fifteenth-magnitude comet P/2010 H2 Vales is probably better suited for astrophotography. The comet is interesting because it appears to keep track with Vesta, travelling along a parallel path just north of the asteroid. It is best seen from 17 December onwards, when it will be able to reach a higher position against a darker sky. Mag. +10.4 comet 24P/Schaumasse can also be seen in the vicinity, higher in the sky passing through Virgo.

Between 13-16 December, a waning crescent Moon joins the party, forming an attractive arrangement with Jupiter and Mars. The presence of the Moon will make it hard to find comet 24P/Schaumasse or photograph faint comet P/2010 H2 Vales, and we would recommend waiting for it to clear the area before making an attempt. Any morning after 16 December from around 06:00 UT should be fine.

Mars and Jupiter appear to converge towards the end of the month, ahead of a very close encounter during the first week of January 2018. The planets appear separated by 24 arcminutes on the morning of 6 January and by just 14 arcminutes on 7 January.

A BIG MOON

WHEN: 3 December, all night long

The Moon is full on 3 December at 15:48 UT. It also reaches perigee, its closest orbital position to Earth, 17 hours later, making this the perigee full Moon for 2017. For those directly under the Moon at 15:48 UT, it will appear slightly larger and brighter than the other full Moons of the year.

Compared to the apparent size of the apogee full Moon, the one which occurs when the Moon is farthest from Earth, the difference can be as much as 14%. In reality, these extremes never occur next to one another in the lunar calendar, being separated by approximately six months. This month's perigee full Moon will also be beaten by the one due to occur next month on 2 January, the perigee full Moon for 2018.

A popular unofficial term encompassing perigee full Moons is 'Supermoon'. This original astrological definition describes the situation when a full or new Moon occurs within 90% of the perigee or apogee distance; closer than 361,430km or farther than 401,670km. The correct astronomical definitions for these situations are apogee-syzygy or perigee-syzygy Moons. The term 'syzygy' describes when three bodies in a gravitational system appear in a line. This is the case with the Sun, Earth and Moon when the Moon is either full or new.


This month's full Moon will be the biggest and brightest of the year

THE NORTHERN HEMISPHERE IN DECEMBER

KEY TO STAR CHARTS

- Arcturus — STAR NAME
- PERSEUS — CONSTELLATION NAME
- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- THE MOON, SHOWING PHASE
- COMET TRACK
- ASTEROID TRACK
- STAR-HOPPING PATH
- METEOR RADIANT
- Cricket — ASTERISM
- PLANET
- QUASAR

STAR BRIGHTNESS:

- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER

- COMPASS AND FIELD OF VIEW

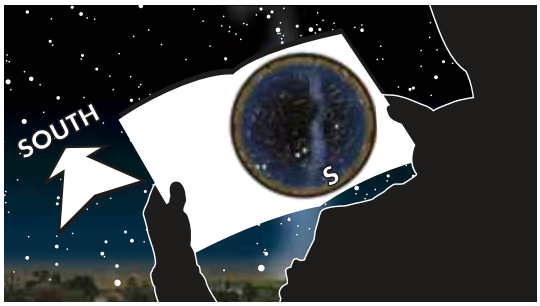
MILKY WAY

WHEN TO USE THIS CHART

1 DEC AT 00:00 UT
15 DEC AT 23:00 UT
31 DEC AT 22:00 UT

On other dates, stars will be in slightly different places due to Earth's orbital motion. Stars that cross the sky will set in the west four minutes earlier each night.

HOW TO USE THIS CHART



1. **HOLD THE CHART** so the direction you're facing is at the bottom.
2. **THE LOWER HALF** of the chart shows the sky ahead of you.
3. **THE CENTRE OF THE CHART** is the point directly over your head.

SUNRISE/SUNSET IN DECEMBER*

DATE	SUNRISE	SUNSET
1 Dec 2017	08:02 UT	15:55 UT
11 Dec 2017	08:15 UT	15:50 UT
21 Dec 2017	08:23 UT	15:52 UT
31 Dec 2017	08:26 UT	16:00 UT

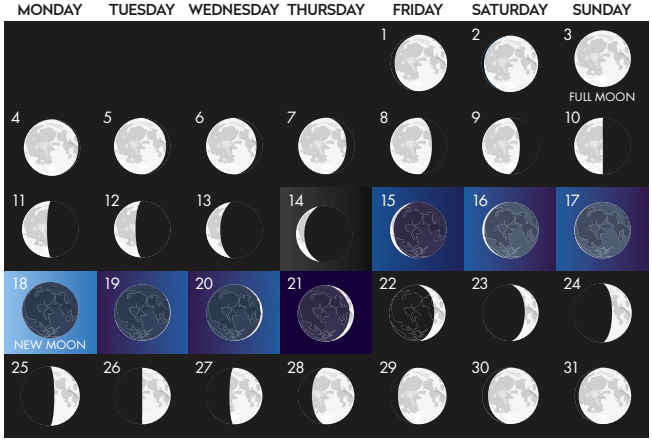
MOONRISE IN DECEMBER*

MOONRISE TIMES

1 Dec 2017, 15:12 UT	17 Dec 2017, 07:08 UT
5 Dec 2017, 18:13 UT	21 Dec 2017, 10:19 UT
9 Dec 2017, 23:11 UT	25 Dec 2017, 12:05 UT
13 Dec 2017, 02:46 UT	29 Dec 2017, 13:39 UT

*Times correct for the centre of the UK

LUNAR PHASES IN DECEMBER



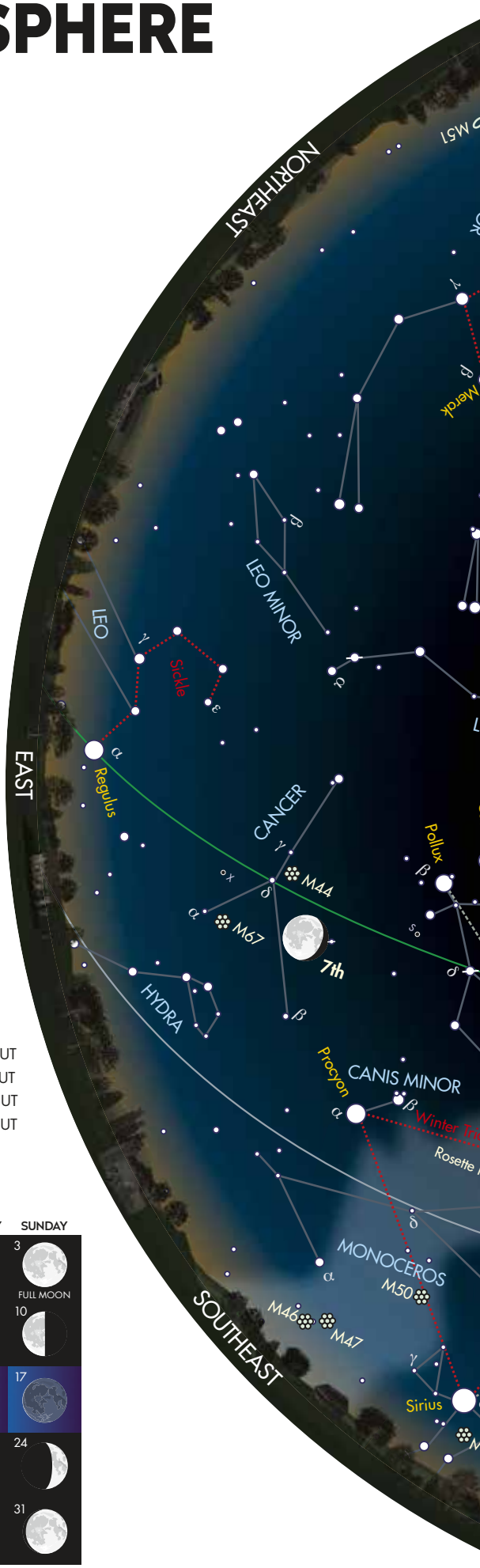
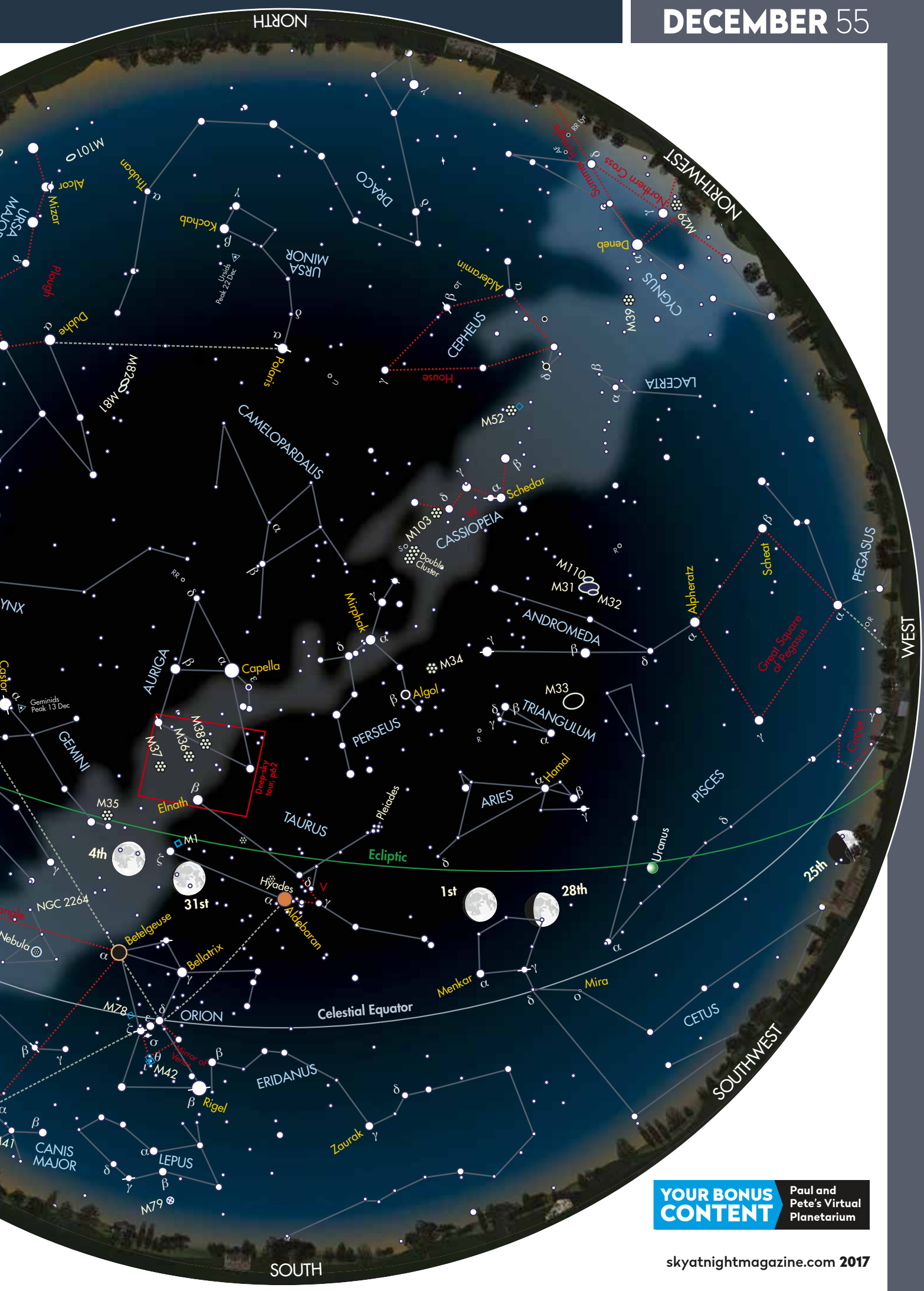


CHART: PETE LAWRENCE



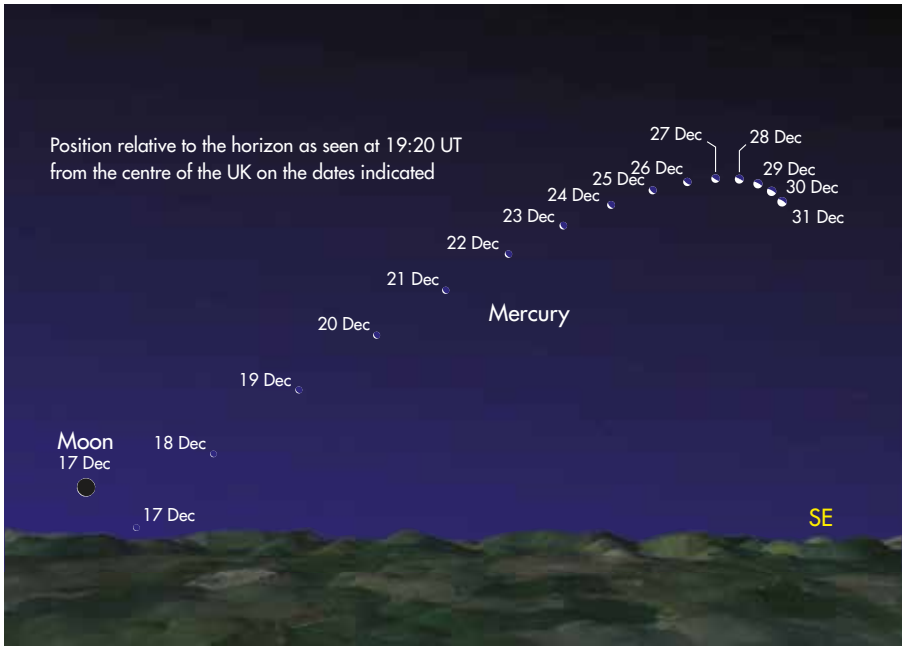
YOUR BONUS CONTENT Paul and Pete's Virtual Planetarium

THE PLANETS

PICK OF THE MONTH

MERCURY

BEST TIME TO SEE: 31 December, 07:20 UT
ALTITUDE: 5° (low)
LOCATION: Ophiuchus
DIRECTION: Southeast
FEATURES: Phase, surface markings through larger instruments
EQUIPMENT: Naked eye, 8-inch telescope to see the disc



▲ Mercury becomes easier to see through the month, as it heads towards western elongation

Mercury can be glimpsed low in the southwest just after sunset at the start of the month. The planet is dimming at this time and falls from mag. +0.2 on the 1st to mag. +1.5 by the 6th, when it will appear just 1.25° from mag. +0.9 Saturn. Look for the pair low in the southwest 25 minutes after sunset. Note that they will be very low at this time, so a flat horizon in that direction will be required to see them.

Mercury reaches inferior conjunction on 12 December, after which it rapidly reappears in the morning sky. It appears to pass mag. –3.8 Venus by a little over 2° on 15 December but, both planets being very close to the Sun, the chances of seeing this conjunction are slim. This won't be helped by Mercury being a rather dim mag. +3.7. By 17 December Mercury will have brightened to mag. +2.4, and can be seen 1° south of an extremely thin waning crescent Moon. Planet and Moon will be above the southeast horizon about one hour before sunrise.

Things rapidly improve over the following mornings, with the planet appearing to move ever further from the Sun. As it does so, its brightness continues to increase and this makes locating Mercury in the dawn twilight, low above the southeast horizon that bit easier to do.

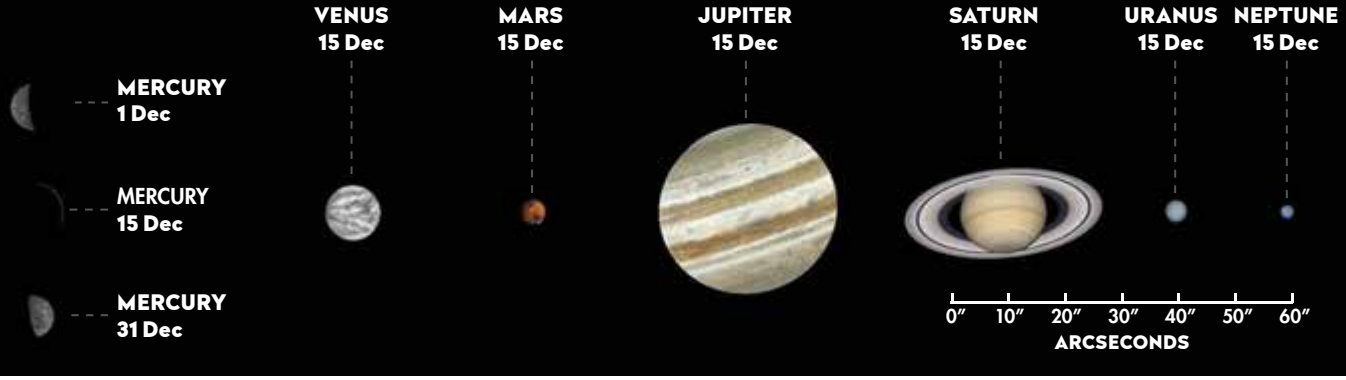
On the morning of 31 December, Mercury rises almost two hours before the Sun and will appear at mag. –0.2. The planet reaches greatest western elongation on 1 January 2018, when Mercury will appear separated from the Sun by 22.7°. This is a great way to welcome the New Year in if you're a fan of the Solar System's inner planet.

PETE LAWRENCE X 3

▲ With an 8-inch or larger scope you may be able to spot surface markings

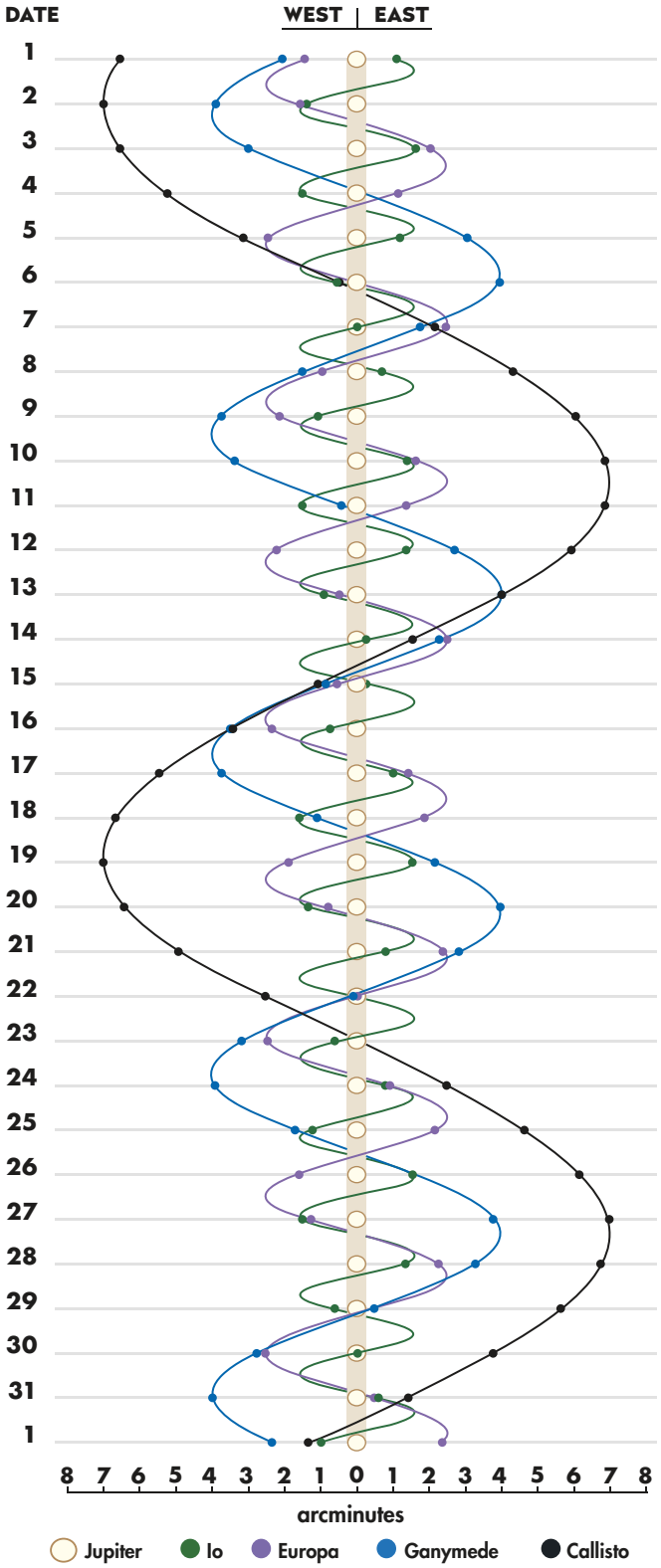
THE PLANETS IN DECEMBER

The phase and relative sizes of the planets this month. Each planet is shown with south at the top, to show its orientation through a telescope



JUPITER'S MOONS DECEMBER

Using a small scope you'll be able to spot Jupiter's biggest moons. Their positions change dramatically during the month, as shown on the diagram. The line by each date on the left represents 00:00 UT.



VENUS

BEST TIME TO SEE:
1 December, 30 minutes before sunrise
ALTITUDE: 2° (low)
LOCATION: Libra
DIRECTION: Southeast

We lose Venus from view this month: the planet rises 50 minutes before the Sun on the 1st but with it by month end. Your last opportunity to see it will probably be during the first week of December.

MARS

BEST TIME TO SEE:
31 December, from 05:00 UT
ALTITUDE: 11°
LOCATION: Libra
DIRECTION: Southeast

Mars remains a morning object heading towards the much brighter planet Jupiter. Mars, appearing as an orange mag. +1.4 star, is outshone by the mag. –1.7 gas giant. Through a scope, Mars is rather small at around 4.9 arcseconds across. The planet is part of a nice arrangement along with mag. +1.0 Spica (Alpha (α) Virginis), a 21%-lit waning crescent Moon and Jupiter on the morning of 13 December. On the morning of the 31st, Mars and Jupiter will appear 3° apart, with mag. +2.8 Zubenelgenubi (Alpha (α) Librae) just south of the mid-point between the two planets.

JUPITER

BEST TIME TO SEE:
31 December, 07:00 UT
ALTITUDE: 18°
LOCATION: Libra
DIRECTION: South-southeast

Jupiter is a morning object that gets better through the month. On 1 December it shines at mag. –1.7 and appears 31 arcseconds across through the eyepiece. By the 31st it will have brightened fractionally to mag. –1.8 and appear 34 arcseconds across. It never quite manages to make it to its highest point in darkness during the month. The 31st also sees Jupiter 3° east of Mars, and they form a triangle with mag. +2.8 Zubenelgenubi (Alpha (α) Librae). Jupiter makes a close 43-arcminute pass of this star on the morning of the 22nd. A thin waning crescent Moon is close to Jupiter on the mornings of the 14th and 15th.

SATURN

BEST TIME TO SEE:
1 December, 30 minutes after sunset
ALTITUDE: 4° (low)
LOCATION: Sagittarius
DIRECTION: Southwest

Saturn is largely lost from view, but may just be visible close to the southwest horizon 30 minutes after sunset at the start of the month. It reaches conjunction with the Sun on the 21st.

URANUS

BEST TIME TO SEE:
1 December, 21:00 UT
ALTITUDE: 46°
LOCATION: Pisces
DIRECTION: South

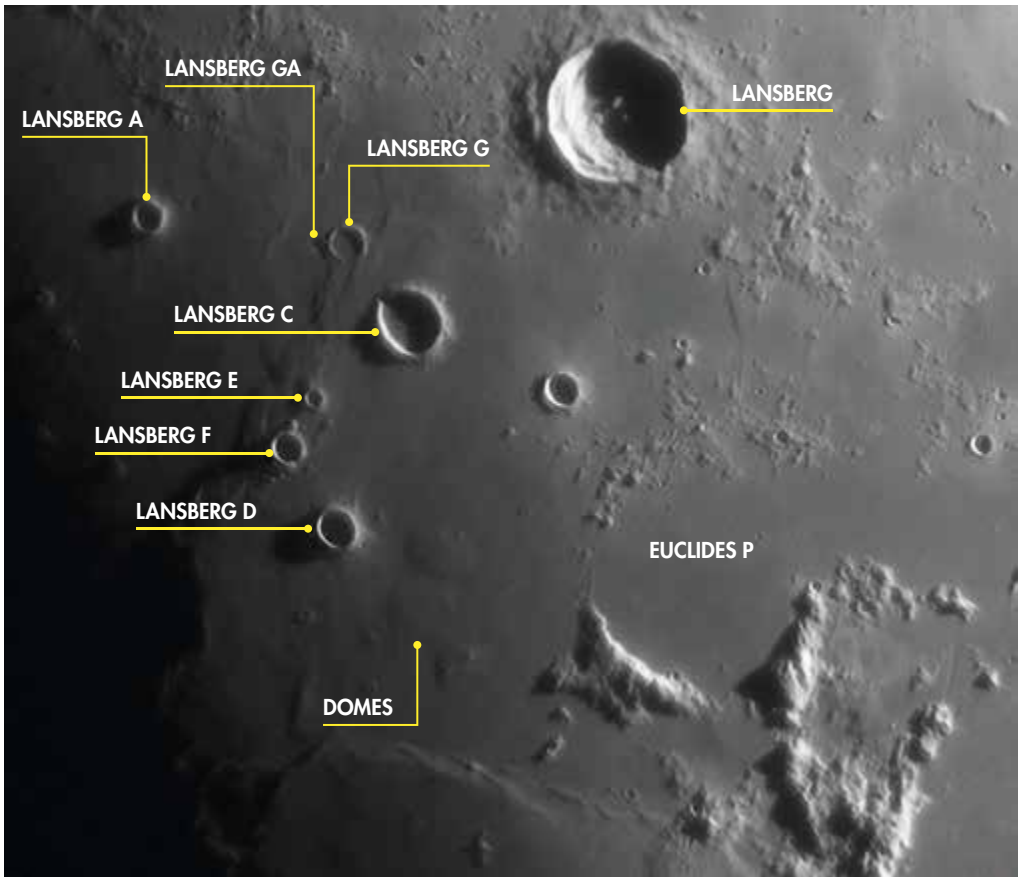
Mag. +5.7 Uranus is well positioned, reaching its highest point in the sky during darkness all month. It does this earlier with each passing day, reaching this position at 21:00 UT on the 1st but 19:00 UT at month end. Although its 3.6-arcsecond disc doesn't easily give up any secrets, it's worth viewing just to see its wonderful greenish hue.

NEPTUNE

BEST TIME TO SEE:
1 December, 18:20 UT
ALTITUDE: 29°
LOCATION: Aquarius
DIRECTION: South

Neptune is well placed at the start of December. On the 1st it reaches its highest point due south in true darkness around 18:20 UT. However, its situation soon deteriorates, moving farther to the west of south after the 6th, and consequently lower in the sky. At month end Neptune is mag. +7.9 and can be found 0.5° south of mag. +3.7 Lambda (λ) Aquarii. A 33%-lit waxing crescent Moon lies 2.8° to the southwest of the planet in the early evening on 24 December.

YOUR BONUS CONTENT Planetary observing forms

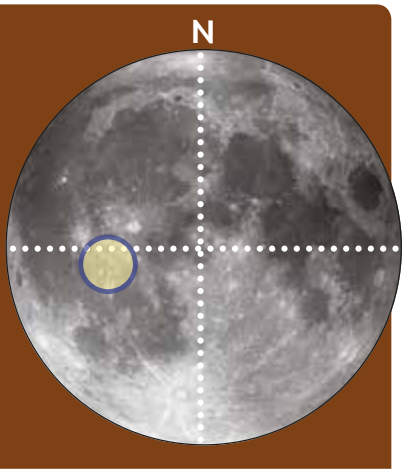


◀ There are a number of smaller satellite craters associated with Lansberg, many of which are worthy of exploration in their own right

MOON**WATCH**

LANSBERG

TYPE: Crater with domes
SIZE: 40km
LONGITUDE/LATITUDE: 26.6°W, 0.3°S
AGE: Between 3.2 and 3.8 billion years old
BEST TIME TO SEE: Two days after first quarter (27-28 December) or one day after last quarter (12 December)
MINIMUM EQUIPMENT: 2-inch refractor



Lansberg is a sharply-defined, 40km-diameter crater located on the Mare Insularum, in a region of the lunar surface bordering the Oceanus Procellarum and the Mare Nubium, with the Mare Cognitum to the south. The best way to find Lansberg is via the impressive ray crater Copernicus (93km wide). Starting at Copernicus, head south, straying slightly west until you arrive at crater Reinhold (48km). Follow the line from Copernicus through Reinhold for about two-thirds that distance again, veering slightly to the west. This should take you directly to Lansberg.

Lansberg is remarkably well preserved for its age, its rim sharp and continuous all the way around. The inside of the crater wall shows some good terracing, and the highest point of rim towers 3km over the flat floor below. The western edge is the lowest, rising to around 2.1km. The crater's floor is flat with a double peak in the centre.

The area surrounding Lansberg is lava filled, fairly flat and dark. Several strips of lighter material ejected from the impact that formed Copernicus can also be seen. A number of small but prominent craters lie west and southwest of Lansberg. These are notable because of their varied appearance. Several show bright petal-like ejecta patterns, notably Lansberg A (9km), B (10km), D (10km) and E (6km). Lansberg C (20km), F (9km) and G (10km) appear as ring formations, their interiors having been flooded by lava.

Of particular interest is Lansberg G, or rather the region immediately to the west of this crater. Here you'll find a small feature often depicted on charts as a tiny 5km crater labelled Lansberg GA, with a rim that touches Lansberg G. However, the feature is complex and irregular in shape, appearing less like a true crater when viewed at high magnification. An 8-inch or larger telescope should start to give a decent view of this curious region.

Lansberg D is an interesting feature too, well worth investigating when the sunrise terminator lies just to the west – approximately three days after first quarter. Positioned to the southeast of the main crater are three prominent lunar domes that stand out very well when the illumination is oblique. Two of the domes are elliptical in shape measuring 18-20km across. The third is more triangular in shape, apparently connected to the southeast edge of the more southerly elliptical dome.

When the illumination is low, it is possible to see numerous wrinkle ridges in the surrounding lava, regions where the surface of the Moon has buckled and cracked as the lava has cooled. A notable ridge runs south from Lansberg G, immediately west of Lansberg E and F. Another can be seen passing west-east south of the Lansberg D domes mentioned above.

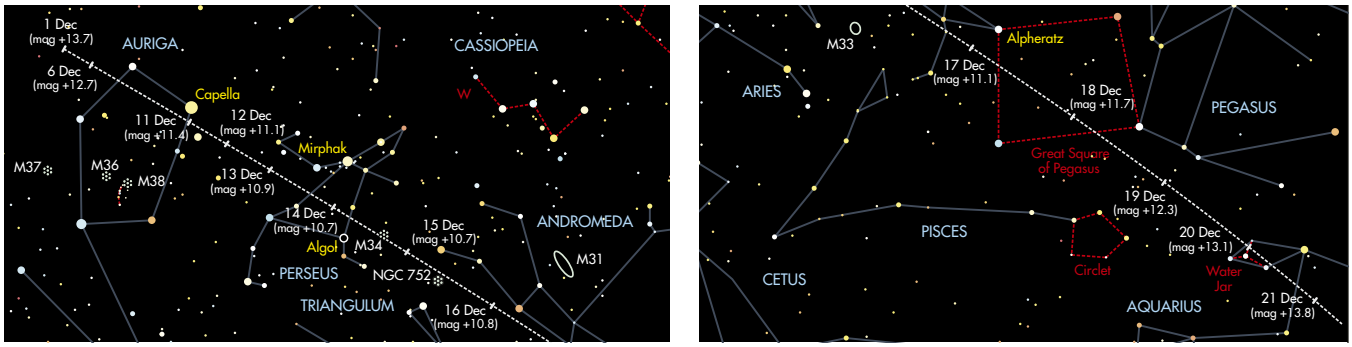
While in the region, it's also worth checking out the huge, partial crater Euclides P. At 66km in diameter it is notably larger than Lansberg and significantly larger than its primary, the 12km ray crater Euclides, located farther to the south-southwest. Euclides P shows a semi-circular southern rim which gets lost in the lava towards the north. Interestingly, the crater still manages to retain its elliptical form thanks to rough terrain to the north, the southern edge of which arcs around to hint at the outline of the original crater.

"Lansberg is well preserved for its age, its rim sharp all the way around"

PETE LAWRENCE X 3

COMETS AND **ASTEROIDS**

Asteroid 3200 Phaethon, the space rock behind the impressive Geminid meteor shower



▲ **Asteroid 3200 Phaethon's positions and magnitudes during the best viewing periods in December; positions are correct for 00:00 UT**

Asteroid 3200 Phaethon is the parent body for the Geminid meteor shower. Typically, meteoroid streams are associated with comets. As a comet passes close to the Sun, material is released from its nucleus. Over time this material spreads along the comet's orbital path, some behind and some ahead of the nucleus. If Earth crosses the debris stream, a meteor shower occurs.

Phaethon is different because it's an asteroid and it is likely that its highly elliptical orbit plays a major role in creating the debris stream that produces the Geminids. Phaethon is classed as an Apollo asteroid, an object which has an Earth-crossing orbit with a semi-major axis larger than 1 AU and a perihelion distance closer to the Sun than Earth. Phaethon's orbit takes it to 0.14 AU (20.9 million km) from the Sun.

As it approaches perihelion, it's thought that its surface temperature reaches 750°C. At this temperature the Sun's energy may cause cracks in the surface through which dust is ejected and dust tails have been seen from spacecraft. However, before concluding that the mechanism that produces the Geminids has been identified, consider that this 'rock comet' model wouldn't be able to produce enough material to account for the amount of dust in the Geminid stream. Another theory suggests that Phaethon may be the core of a dead comet. It is known to be 5.1km in diameter, which is again rather small for the amount of material seen.

This month there's a rare opportunity to spot Phaethon with a small scope, as it makes a close pass of Earth. On the 10th it will pass 0.069 AU (10.3 million km) from our planet. In the period around this time it should reach a peak of mag. +10.7. Whatever the actual origin, the resulting shower is reliably good and conditions are favourable this year.

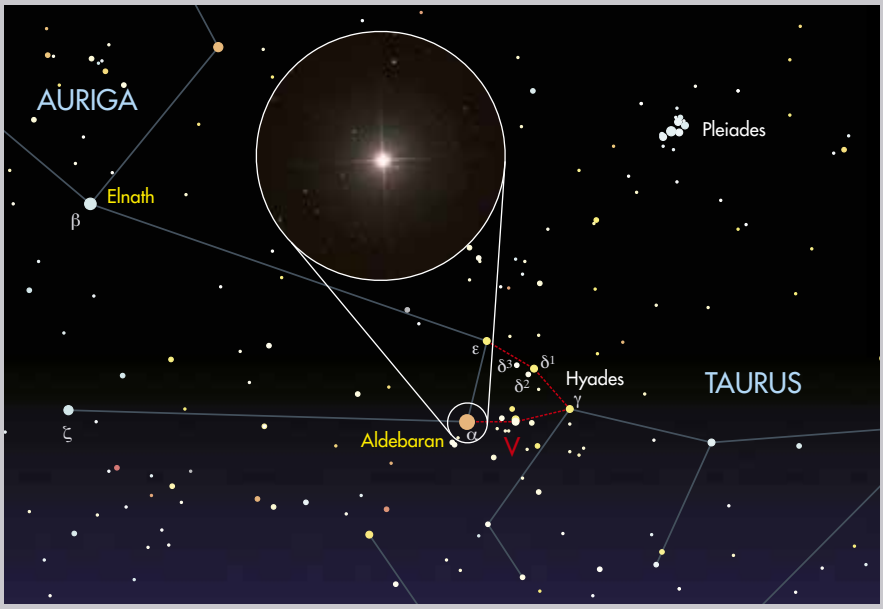
STAR OF **THE MONTH**

Aldebaran – the fiery eye of Taurus, the Bull

Aldebaran (Alpha (α) Tauri) is one of the more prominent stars of the autumn and winter skies. It is an orange giant star, shining at mag. +0.9 with a slight variability of 0.2 magnitudes. Aldebaran is particularly easy to locate – just extend the line of Orion's Belt northwest. It appears to be associated with the V-shaped Hyades open cluster, lying at the end of the V's southern arm, yet this is another instance where appearance is deceiving – the 153 lightyear-distant cluster is roughly twice as far as Aldebaran, which is 65.3 lightyears away.

Aldebaran is 425 times more luminous than the Sun, and the most luminous star within 100 lightyears of Earth. It is also one of the closest giants, with a diameter estimated to be 44 times that the Sun. If you replaced our Sun with Aldebaran, it would have an apparent diameter of around 22°.

Its close proximity and large physical diameter means Aldebaran presents a disc large enough to measure. Even so, this is very small at just 0.021 arcseconds. A gas giant planet several times the size of Jupiter may orbit the star: its existence was suggested in 1993, but remained doubtful until a 2015 study provided long-term evidence to back up the claim. From Earth, a number of faint stars appear close to Aldebaran. One of these, Alpha Tauri B, appears to have a similar distance and motion to Aldebaran. However, being faint at mag. +13.6 and only separated from its bright host by half an arcminute, it is difficult to confirm or deny whether it is a true, physically bound companion.



▲ **Aldebaran's name translates as 'follower', a reference to it chasing the Pleiades through the sky**

STEPHEN TONKIN'S
BINOCULAR TOUR

December leads us into Cetus, where a cosmic question and an almost stellar galaxy await

☑ Tick the box when you've seen each one

1 ZIBAL

10x 50 Zibal (Zeta (ζ) Eridani) is an easy double star located 4.75° east of mag. +3.9 Azha (Eta (η) Eridani). Zibal is a pure white star that shines at mag. +4.8; look 5 arcminutes northwest to find its golden, mag. +6.6 companion. This is a line of sight pairing: the companion is intrinsically 1.6 magnitudes brighter, but appears 1.8 magnitudes fainter due to the fact it is four times farther away. ☐ SEEN IT

2 THE QUESTION MARK

10x 50 We continue with a good star party piece. Identify mag. +2.5 Menkar (Alpha (α) Ceti) and move 7° west to Nu (ν) Ceti. This mag. +4.9 yellow-white star is the dot at the bottom of a 2.25° 'question mark', which can be seen directly above when the Nu Ceti is in the south. The curve of the question mark is comprised of four yellowish 6th-magnitude stars, whilst the 7th-magnitude star in the middle of the upright is a brilliant white. ☐ SEEN IT

3 M77

15x 70 Mag. +8.9 galaxy M77 is considerably more challenging to see, and ideally should be viewed under a dark, transparent sky. It is, however, easy to locate – look 52 arcminutes east of mag. +4.1 Delta (δ) Ceti. Compact and nearly round, M77 could easily be confused for a globular cluster. It is a Seyfert galaxy, meaning that most of its light comes from an active nucleus where gas is spiralling into a black hole. This makes it quite easy to see the nucleus, but any light pollution will obscure the galactic disc. As a result the galaxy looks stellar, and thus is difficult to identify in binoculars. ☐ SEEN IT

4 MIRA

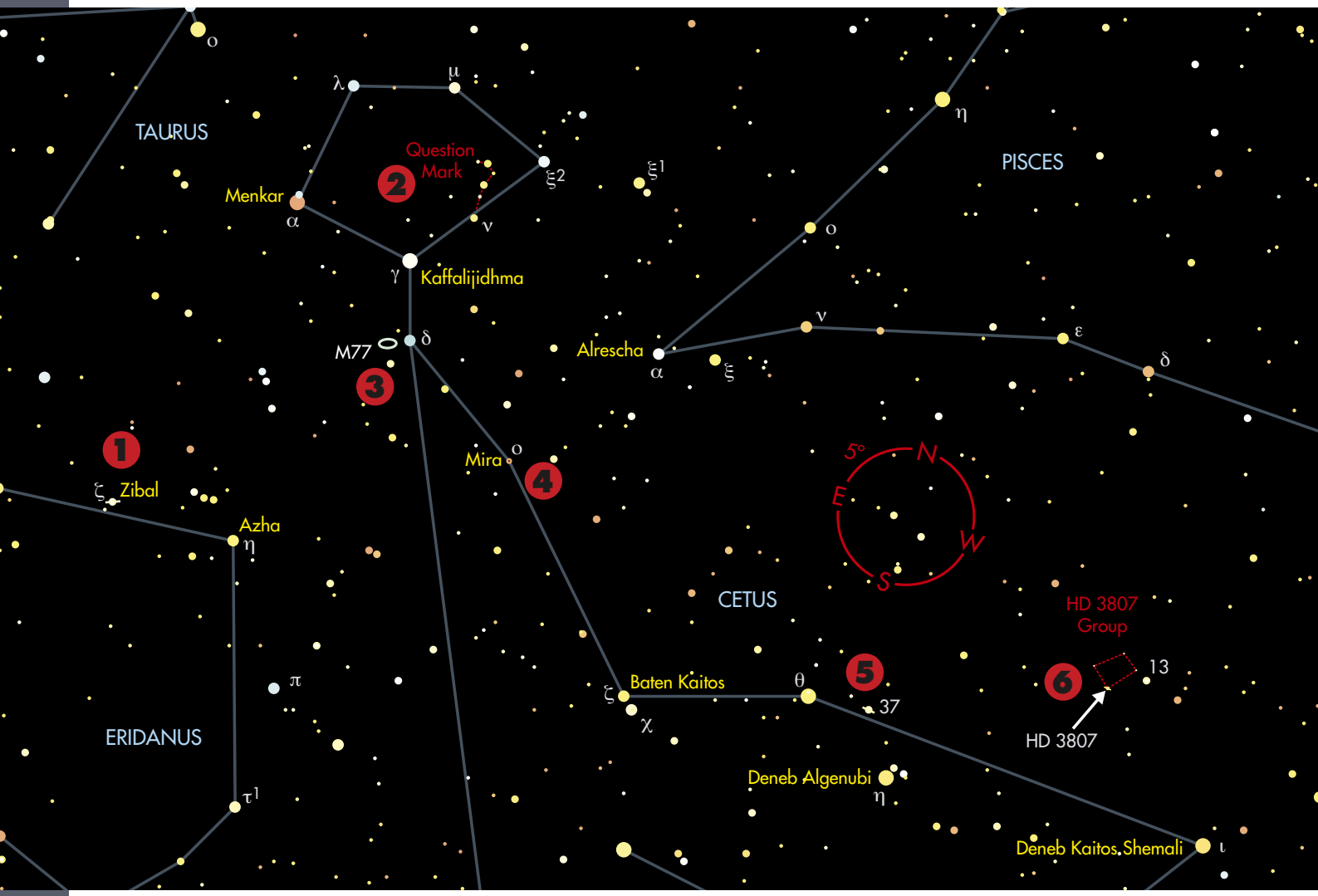
10x 50 This star is the prototype of a whole class of objects, the Mira variable stars. Mira (Omicron (ο) Ceti), the name of which derives from the Latin 'mirabilis' (meaning 'amazing'), brightens from mag. +9.3 to +3.4 every 11 months, and will reach peak brightness once more in January. Mira variables are red giants in the late stage of their evolution. They pulsate in size; as they expand, they cool and radiate a higher proportion of their luminosity in infrared. As a result much less optical light is emitted and they disappear to the human eye. ☐ SEEN IT

5 37 CETI

15x 70 If you look 1.5° northwest of the middle of a line between mag. +3.5 Deneb Algenubi (Eta (η) Ceti) and mag. +3.6 Theta (θ) Ceti you will see a mag. +5.1 star that makes an isosceles triangle with the these two. This is the double star 37 Ceti. Its components are 49 arcseconds apart, which should be an easy split even using lower magnifications, but the magnitude of the companion is only +7.9, which is 13 times dimmer. This magnitude difference can make it tricky to split, so we'd recommend using 15x70s and mounting them for steadiness. ☐ SEEN IT

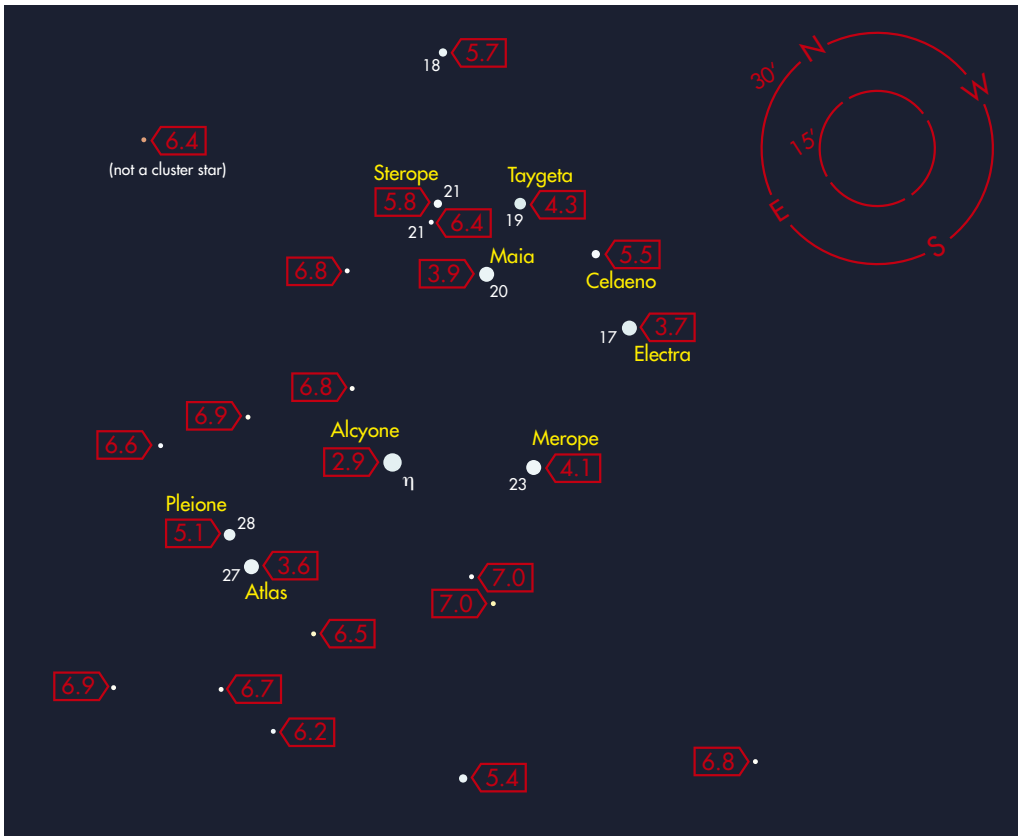
6 HD 3807 GROUP

10x 50 Imagine a line joining Deneb Algenubi and mag. +3.6 Deneb Kaitos Shemali (Iota (ι) Ceti); running parallel, approximately 5° north, is a 6°-long row of six 6th- and 7th-magnitude stars. The brightest of these is 13 Ceti. The star 1.5° to its east-southeast is HD 3807. This is the southern corner of a rectangular asterism with diagonals of about 1.25°. The rectangle is brighter on the southeastern side and has a void in the northern quadrant. HD 3807 itself is a double star, shining at mag. +8.4 secondary that lies 63 arcseconds to the west. ☐ SEEN IT



THE SKY GUIDE **CHALLENGE**

Can you count more than seven stars in the Seven Sisters, the Pleiades cluster in Taurus?



▲ **There are 22 stars of mag. +7.0 or brighter in the Pleiades**

The Pleiades open cluster is one of the more iconic sights of the autumn and winter night skies. Easily visible to the naked eye, it is large enough for you to be able to make out a number of its key members and its overall shape. This month's challenge is to push your eyesight to the limit and see how many stars you can count within it.

An alternative name for this cluster is the Seven Sisters, so you might be forgiven for thinking you have a shortcut to the answer. However, it is possible to see more than seven stars, and as a number of these lie close to the threshold of visibility you may find yourself becoming obsessed with trying to outdo your previous best.

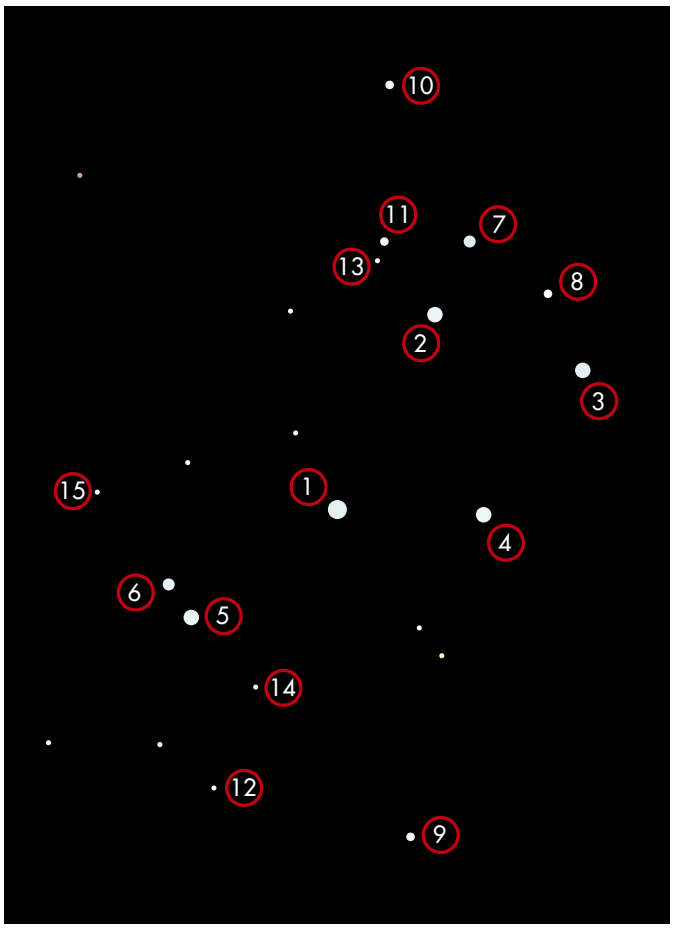
One danger of describing the stars is that it pre-programmes your mind with what it should be seeing. The mere suggestion that a star may exist in a particular position may be enough to make you think you've seen it. This is a common issue with threshold observations. Ultimately it's up to you to make an assessment as to how likely it is that you're seeing is actually real!

Sky transparency, darkness and allowing your eyes to the dark are all important. Another often overlooked factor is your comfort. If you are standing uncomfortably, the likelihood of a good count is reduced. It's a good idea to sit or lie back on a chair and relax before starting the count. Give your eyes at least 20 minutes to acclimatise too.

The brightest cluster star is Alcyone (Eta (η) Tauri), which at mag. +2.9 should be easy to spot. Alcyone is part of a box shape that extends to the west, which also includes mag. +3.9 Maia (20 Tauri), mag. +3.7 Electra (17 Tauri) and mag. +4.1 Merope (23 Tauri). The box appears to have an east-pointing 'handle', the end of which is marked by mag. +3.6 Atlas (27 Tauri).

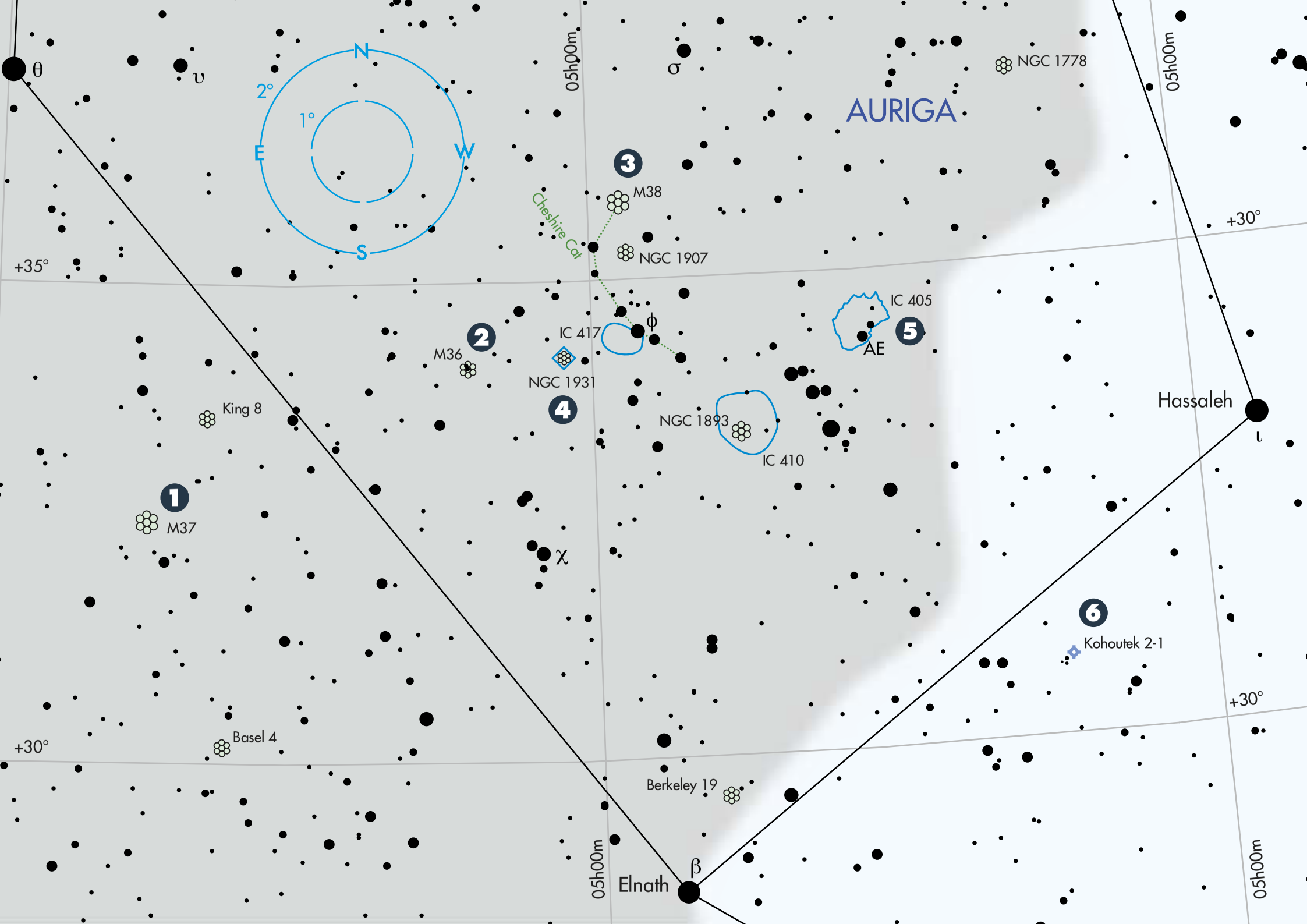
So far, none of the targets should have presented too much trouble if you have reasonable eyesight, giving you a count of five. Now things start to get harder. First, look immediately above Atlas where you should be able to see mag. +5.1 Pleione (28 Tauri). The separation of Atlas and Pleione is one-fifth the length of the 'handle' (Alcyone to Atlas). Mag. +4.3 Taygeta (19 Tauri) should help you get the count up to seven; it is relatively easy spot, located just northwest of Maia.

Mag. +5.5 Celaeno (16 Tauri) is harder because it's relatively faint, but it is better positioned that Taygeta, slightly west of the mid-point between Maia and Electra. If you've made it this far you're up to eight and ready for the next level. Using our charts, see how many of the additional cluster stars you can spot.



▲ **Our recommended counting sequence; 10 or more is excellent**

PETE LAWRENCE X 3


AURIGA
N
E
W
S
2°
1°
θ
υ
σ
05h00m
NGC 1778
3
M38
Cheshire Cat
NGC 1907
+35°
+30°
IC 405
AE
5
φ
2
IC 417
M36
NGC 1931
4
King 8
NGC 1893
IC 410
Hassaleh
ι
1
M37
χ
6
Kohoutek 2-1
Basel 4
Berkeley 19
Elnath
β

DEEP-SKY TOUR

This month we wheel through the southern limits of Auriga, the Charioteer

☑ Tick the box when you've seen each one

1 M37

The misshapen pentagonal form of Auriga, the Charioteer, plays host to some excellent deep-sky objects, the most famous being three open clusters of the Messier catalogue, all of which are found in the constellation's southern region. Mag. +5.6 M37 is our first target; it can be found almost 5° south and fractionally west of mag. +2.7 Theta (θ) Aurigae. It's a rich open cluster and a great target for smaller instruments. Use a low power and then gradually increase the magnification until you get to the most pleasing view. The cluster contains around 150 stars down to 12th magnitude, grouped into a region approximately 20 arcminutes across. A red 9th-magnitude star shines out from the centre. This cluster is 4,400 lightyears from Earth. ☐ **SEEN IT**

2 M36

M36, the Pinwheel Cluster, is 3.75° west-northwest of M37. Visually it is less impressive than M37, having fewer members and – occupying an area approximately 12 arcminutes across – being roughly half its size. Despite this it's still a lovely sight through a small instrument, with a 6-inch scope bringing approximately 60 stars into view. A good number of these are blue-white in colour and bright, at around the mag. +9.0 mark. Outlying stars appear to create an almost cruciform shape, with the intersection of the cross falling at the cluster's core. M36 is 4,100 lightyears and shines at mag. +6.3, just below the threshold of naked-eye visibility. ☐ **SEEN IT**

3 M38

At mag. +7.4, M38 is fainter than its two Messier stablemates, but its 21-arcminute apparent diameter is comparable with that of M37. The cluster is 2.3° northwest of M36 and appears quite loose. It has a very irregular outline and is heavily peppered with 10th- and 11th-magnitude member stars. Look out for the fainter and smaller open cluster NGC 1907, just 0.5° to the south of M38. It has a magnitude of +8.2 and appears 6 arcminutes across, approximately one-third the size of its larger neighbour. NGC 1907 is 4,500 lightyears away and is estimated to be 500 million years old. In comparison, M38 is a youngster, being 200 million years old and lying 4,200 lightyears away. ☐ **SEEN IT**

4 NGC 1931

Mag. +11.7 NGC 1931 is located approximately 1° west of M36. This is a cluster with a surrounding nebula made up of reflection and emission components. The presence of tightly packed stars at the heart of the emission section have drawn parallels with the Trapezium Cluster at the heart of M42, and NGC 1931 is sometimes described as a miniature Orion Nebula. The nebula stretches to 3 arcminutes, although most views show it to be elongated and roughly half this size. A large patch of diffuse nebulosity known as IC 417 sits 42 arcminutes to the west. In long-exposure images they are collectively termed the 'Spider and the Fly', NGC 1931 being the fly. ☐ **SEEN IT**

5 IC 405

IC 405, the Flaming Star Nebula, is a popular target for astro imagers, but a tricky object to glimpse visually. It is 3.1° to the west of NGC 1931 and surrounds 6th-magnitude AE Aurigae, a runaway star ejected from the Trapezium Cluster in M42 some two million years ago. AE Aurigae isn't associated with the nebula, but passing through it at high speed. As it does this a bow shock from the interaction produces the energy required to make the nebula glow. A transparent night is required to see anything of IC 405. Use a low power eyepiece and, with properly dark-adapted eyes, the Flaming Star Nebula should appear as a weak, curving glow. ☐ **SEEN IT**

6 KOHOUTEK 2-1

Kohoutek 2-1 is a mag. +13.8 planetary nebula close to the border of Auriga and Taurus. Imagine a line between mag. +1.7 Elnath (Beta (β) Tauri) and mag. +2.7 Hassaleh (Iota (ι) Aurigae). Look southwest of the line's midpoint to find two stars of around mag. +6.6, then extend the line between them west. You will reach a pair of 9th-magnitude stars; the planetary nebula is 3 arcminutes northeast of the northern star. Unusually, a low power works better than a high power here. An OIII filter will also help. The nebula has a diameter of 2.2 arcminutes and should appear as a circular glow. Sections of its edge appear brighter, giving the overall appearance of a pair of brackets enclosing the inner glow. ☐ **SEEN IT**

◂ **The Flaming Heart Nebula, IC 405, is lit by the bow shock of a runaway star speeding through it**

THIS DEEP-SKY TOUR HAS BEEN AUTOMATED

ASCOM-enabled Go-To mounts can now take you to this month's targets at the touch of a button, with our Deep-Sky Tour file for the EQTOUR app. Find it online.

YOUR BONUS CONTENT

Print out this chart and take an automated Go-To tour

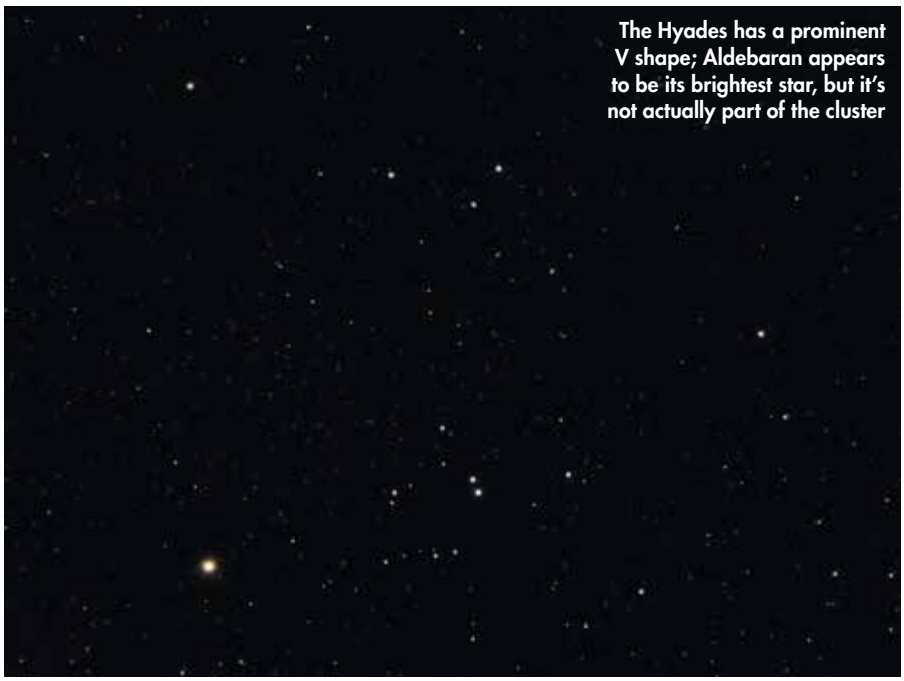
CHART: PETE LAWRENCE, PHOTO: FRANZ KLAUSER/CCDGUIDE.COM

ASTROPHOTOGRAPHY

The Hyades cluster, the head of Taurus

RECOMMENDED EQUIPMENT

DSLR with shutter release cable, tripod or tracking mount



The Hyades has a prominent V shape; Aldebaran appears to be its brightest star, but it's not actually part of the cluster

The Hyades open cluster is a prominent deep-sky object in Taurus. It's easily found by extending Orion's Belt up to the northwest, where eventually you'll arrive at the bright orange star Aldebaran (Alpha (α) Tauri). Although mag. +0.9 Aldebaran isn't actually part of the cluster, it appears to sit prominently within the sideways V shape formed by the Hyades, marking the end of the V's southern arm.

From here, it's relatively easy to make out the rest of the shape, even through light-polluted skies. It then becomes obvious that this is a large object to deal with photographically. The northern arm of the V is the longest, measuring 4.1°.

This inherently places limits on the photographic setup you can use if you want to capture the V in its entirety. For a non full frame (eg, APS-C) DSLR, you'll need a lens with a focal length of at least 190mm; for a full frame camera the minimum lens focal length is 300mm. Such lenses will allow you to capture the entire V shape, but the fit will be tight.

Fitting and composition are important elements that can really help lift an image from average into something special. Sometimes, just managing to get a large object in frame can be such a relief on its own that the fine nuances of composition are forgotten. However, putting the time and effort into thinking about the composition can transform a clinical astro shot into one with a great deal of aesthetic punch.

The Hyades is supposed to represent the head of Taurus, as the Bull charges eastwards across the sky. With this in mind, the best composition would seem to be to offset the cluster to the right of frame, assuming the apex of the V is to the left. This essentially gives Taurus somewhere to charge into.

If you frame the shot correctly there's another treat on offer too, because off to the east of the V is NGC 1647, a smaller and fainter open cluster that makes a great comparison object when revealed next to the Hyades.

One of the problems associated with strong star shapes occurs when the exposure goes deep. There are lots of stars in and around the Hyades cluster, many of which belong to the cluster itself, but others which are merely line of sight. Increase the exposure depth too much and you'll bring out many of these stars and lose the V shape that makes the Hyades so distinctive. A careful treatment of the brighter stars, actually keeping the exposures quite short, will help preserve the beautiful colours on offer.

Being a bright cluster, photographing the Hyades is an interesting exercise for both experienced and beginner astrophotographers. It's something that can be imaged using very simple setups, including those using non-tracking fixed tripods. A good example of creative composition is to let the cluster trail though the field of view. Keep the length of trailing to just a few minutes and the character and shape of the cluster should remain intact.

If you want to attempt longer tracked exposures, creative techniques such as stopping a camera lens aperture down to create diffraction spikes can produce some interesting effects on the brighter cluster members and, of course, bright Aldebaran.

Our step-by-step guide shows some useful information to help you capture the best shots of this beautiful but often over-looked cluster. With the Hyades well positioned during December when the Moon and clouds are out of the way, have a go and see what you can achieve.

KEY TECHNIQUE

FINDING THE RIGHT FRAMING

The Hyades open cluster is an interesting subject to photograph. Its age and proximity to the Sun means that it appears very spread out in the night sky. Consequently, in order to catch the cluster at its best, some thought has to go into how to frame it and how deep you intend to go with the capture. Unlike a diffuse deep-sky object such as a nebula, longer exposures won't, up to a point, bring much of an advantage in terms of revealing deep detail. Instead, great emphasis has to be put on composition to show the main stars off at their best.

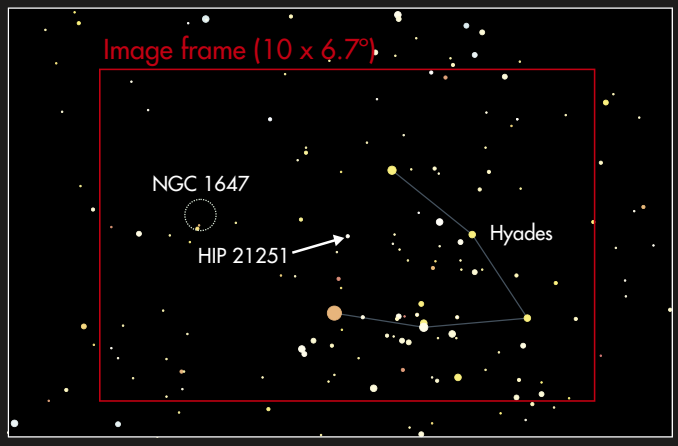
ALL PICTURES: PETE LAWRENCE

✉ Send your image to: hotshots@skyatnightmagazine.com

STEP BY STEP

STEP 1

If you want good framing, you need an appropriate lens; we would recommend one that gives you a frame covering 10° along its longest edge. For non full frame DSLRs, a 120mm lens will achieve this. For full frame sensors, a 200mm lens works well. If you don't have these size lenses, choose one you have that is less than these values.



STEP 2

If you use a lens which gives at least a 10° edge dimension, the V of the Hyades will fit comfortably within the frame. If you place the star HIP 21251 (marked above) at the centre of the frame and align the southern arm of the V so it is more or less parallel to the bottom frame edge, the whole of the Hyades and NGC 1647 should fit in nicely.

STEP 3

One major advantage of imaging bright clusters is the good selection of stars available for focusing. Live view works really well here. At mag. +0.9, Aldebaran is a good choice as is the optical double of Theta^1 (θ^1) and Theta^2 (θ^2) Tauri, which are 1.8° west and slightly south of Aldebaran. Take your time to achieve as accurate a focus as possible.

STEP 4

A deep exposure taken under transparent skies will reveal many faint stars and subtle dust regions; but under average UK skies much of this will be hidden. If using a tracking mount, reduce ISO to around the 200-800 mark to retain tonal quality. For fixed setups use an ISO of 800 to 1600. Set the lens to the lowest f/number, then close it by a few stops.

STEP 5

Your maximum exposure length will depend on your setup, tracking accuracy and sky quality. Experiment using exposures of 30 seconds, 60 seconds, etc. Stacking your shots will help reduce noise. For fixed mounts use the 500 rule: the maximum non-trailed exposure is 500 divided by the lens focal length. As ever, use a remote shutter cable.

STEP 6

If you don't have a tracking mount, you can still obtain interesting shots of the Hyades. One easily achievable shot is to set the camera's ISO to 400 and the aperture to f/8, and expose for a few minutes. The cluster stars will trail through the frame. Keeping the trails relatively short will help preserve the original shape of the cluster so it remains recognisable.

A second chance at FIRST LIGHT

The Isaac Newton Telescope at 50

Formerly part of the Royal Observatory, Britain's Isaac Newton Telescope has undoubtedly come of age. Yet it had a rough start, writes Paul F Cockburn

On La Palma, the observatory sits above an inversion layer, a meteorological phenomenon that traps cloud below

TIBOR AGOCS/ALAMY STOCK PHOTO

When The Queen inaugurated the Isaac Newton Telescope on 1 December 1967, its 98-inch mirror made it the fourth-largest reflector telescope in the world.

"It is often said that our most brilliant young men are tempted to leave the country and join the brain drain because of the lack of first-class equipment for them to work with here," Her Majesty said. "The Isaac Newton Telescope is a move to counter this in so far as astronomy is concerned."

YOUR BONUS CONTENT

We speak to Cecilia Fariña, manager of the Isaac Newton Telescope at the Roque de los Muchachos Observatory in La Palma

Thanks to the likes of Sir Bernard Lovell, post-war Britain was certainly at the cutting edge of radio astronomy and theoretical astrophysics, but optical astronomy was another story. As then-Astronomer Royal Sir Richard van der Riet Woolley put it the day before the Queen arrived, the Isaac Newton Telescope (INT) would enable British astronomers to once again "get into the ▸

Construction of the Isaac Newton Telescope's dome at Herstmonceux in the 1960s...

..and the newly completed dome, as seen in 1967

▲ An astronomer rides in a cradle below the main mirror in this 70s shot

▲ A 30-minute exposure of M51 taken using the telescope in May 1970

▲ The Royal Greenwich Observatory's new base at Herstmonceux, East Sussex, which today is the Observatory Science Centre, was chosen as the first home of the INT

▸ business of studying very faint and interesting objects without begging time from the Americans". Except, it didn't quite work out like that.

Back in 1945, the Royal Society had established a small committee to assess the future of post-war astronomy. Led by Woolley's predecessor, Sir Harold Spencer Jones, the group's initial report suggested that "a reflector of 60-inch aperture at a selected site in the south of England could be effectively used for special observations which are not possible with the largest existing telescopes in this country".

By February 1946, when committee member (and president of the Royal Astronomical Society) Prof Harry Plaskett publicly aired the idea, the proposed primary mirror had already grown to "at least" 72 inches. Spencer Jones, however, disagreed; he believed an "appreciably larger" telescope would be needed to compensate for the vagaries of the British climate and the inevitable shorter exposure times. And so, the INT would eventually get a 98-inch mirror.

A decade of delays

Within a few months, the British Government agreed to foot the bill. It helped that the telescope was to be named after Sir Isaac Newton, meaning the news could be announced during 1946's delayed official celebrations to mark 300 years since Newton's birth. Yet almost immediately the project fell into limbo. "The delays of the next 10 years were mainly due to lack of decision," said Prof Patrick Blackett during his tenure as president of the Royal Society between 1965 and 1970. "The fault lay with the scientists who were concerned with the project. I was one of them, and we must take the blame."

Additional delays included doubts about the quality of the mirror – a gift from the trustees of the McGregor Fund via the University of Michigan – the suitability of the Royal Greenwich Observatory's new home at Herstmonceux in Sussex, and unexpected knocks to government budgets, including the Suez Crisis. Ultimately,

▲ The Queen and Astronomer Royal Richard Woolley at the control console during the 1967 inauguration

▲ Left: Work on relocating the Isaac Newton Telescope to La Palma began in 1979; right: The process of carefully removing the telescope from its dome

it took 21 years and £1 million before the Isaac Newton Telescope completed its 'first light'. Even then it was underwhelming: light drizzle and poor visibility meant the Queen was unable to view Saturn or any notable objects through the telescope.

Though cutting-edge work would eventually be achieved from Herstmonceux – such as Paul Murdin and B Louise Webster's 1971 observations that confirmed the existence of the first stellar-mass black hole, Cygnus X-1– the often wet and cloudy Sussex weather ultimately led to the telescope's relocation to the new, international Roque de los Muchachos Observatory on the island of La Palma in the Canary Islands, a process begun in 1979.

The telescope may have been one of the largest in the world but, in the mind of Dr Marek Kukula, Public Astronomer at the Royal Observatory Greenwich, it did not fulfil its potential during its first few years. "They had their reasons at the ▸

▲ By 1981, work on the new facility that would house the telescope was well underway

▲ A new 100-inch mirror was commissioned to take full advantage of the clearer skies in La Palma

MILESTONES IN THE LIFE OF THE INT

- **December 1942** Tricentenary of Newton's birth; Royal Society postpones celebrations due to the Second World War
- **February 1946** Prof Harry Plaskett, president of the Royal Astronomical Society, calls for a large optical telescope sited in Britain
- **July 1946** The British Government commits to funding the Isaac Newton Telescope
- **1948** The Royal Greenwich Observatory begins its move to Herstmonceux, Sussex
- **August 1949** The 98-inch mirror arrives in London from New York
- **December 1967** The Isaac Newton Telescope is inaugurated by the Queen; first light in Herstmonceux
- **May 1979** Last observations at Herstmonceux before the Isaac Newton Telescope is moved to Roque de los Muchachos Observatory, La Palma
- **February 1984** The Isaac Newton Telescope experiences its second first light

▸ time, but now you just wouldn't put a telescope like that somewhere with such cloudy weather as we have here," he says. Kukula still has "a soft spot" for the INT, which he used during his early observational career in the 1990s.

"It was and still is a really great instrument if you're a young researcher," he says. "I think there are quite a lot of people who have affection for it, because it was one of the first big professional telescopes that they got to use. And it has the wide-field camera, and the intermediate dispersal spectrograph – these are good workhorse instruments, and there's a lot of stuff you can do with them. It's still playing a useful role."

Back in 1967, however, it was just too early to catch the first wave of electronic detectors. "So really it's in the 1980s and 1990s that it does have this second life. It's testament to the great design of the telescope that it's still going strong with this whole new generation of amazing detectors attached to the back of it."

NIK SYZMANEK, MAX ALEXANDER, RGO ARCHIVES/CAMBRIDGE UNIVERSITY LIBRARY, PICTURESBYROB/ALAMY STOCK PHOTO

▲ Above left: The clear skies of La Palma are perfect for the Isaac Newton Telescope

Above right: The Isaac Newton Telescope is a Cassegrain design with a focal length of 8.36m

Right: The original dome in Sussex now stands empty, the skyglow from light pollution having driven its telescope to pastures new

ABOUT THE WRITER

Paul Cockburn has been writing about astronomy, science and technology since 1996. He is based in Edinburgh

THE MOMENT OF TRUTH

Five years after its last observations in England, the Isaac Newton Telescope was ready for its first light in La Palma

The night of 13/14 February 1984 proved to be an important one for the Isaac Newton Telescope: it was the first time it was turned towards the sky above its new home at Roque de los Muchachos Observatory, La Palma. As Sir Patrick Moore wrote afterwards in his then-regular column for the *Illustrated London News*: "That moment of 'first light' marked the real beginning of a new chapter in the story of astronomy in general and British astronomy in particular."

'First light' is an interesting rite of passage for any telescope, or instrument. Few of the resulting astronomical images have much scientific value, as even the smallest telescope needs some on-site fine-tuning to get the best results. Yet there's often a 'wow' factor nonetheless.

The Isaac Newton Telescope, of course, has the rare honour of having had two first lights: its original 1967 opening at the Royal Greenwich Observatory at Herstmonceux, and then – with a new dome and a bigger, 100-inch mirror – in La Palma. Its second first light was recorded using a video camera, delivering images of the Crab and Orion Nebulae, and galaxies M51 and NGC 4151.

Patrick, reporting from La Palma in April for the June 1984 edition of *The Sky at Night*, was particularly impressed by the telescope's first image of the Ring Nebula in Lyra. "All the intricate details in the Ring were enhanced," he later wrote. "It was difficult to believe that we were looking at an object well over 1,000 lightyears away."

The Isaac Newton Telescope (arrowed) is part of a wider network of telescopes in La Palma

BBC Sky at Night MAGAZINE

READER SURVEY

Dear Reader,

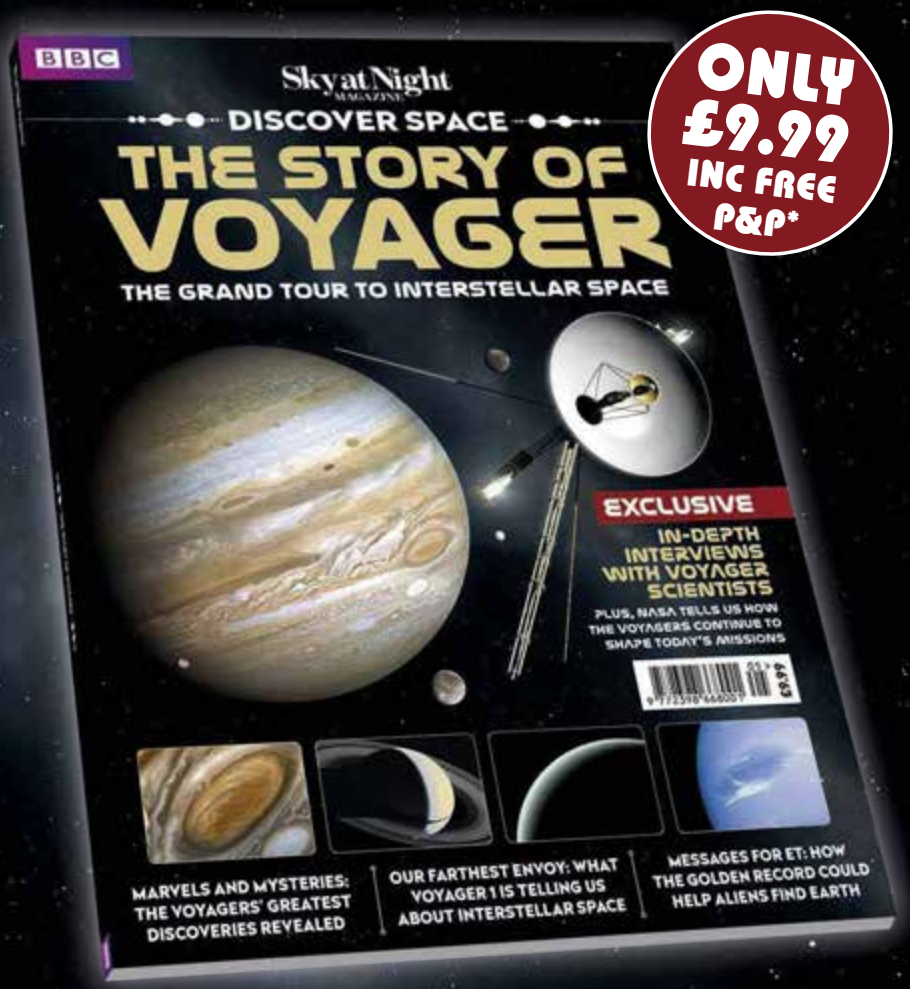
Welcome to our *BBC Sky at Night Magazine* reader survey. This is your chance to tell us what you'd like to see in your magazine, and help shape the content in the future. The more we understand about your hobbies and interests, likes and dislikes, the more relevant and enjoyable we can make our magazine for you.

Visit **www.skyatnightmagazine.com/readersurvey** to give your feedback. Complete and submit the questionnaire by 23:59 on Friday 15 December 2017 and you'll be entered into a **prize draw** for a chance to win **one of five £100 Amazon vouchers**.

We look forward to hearing your thoughts,

Chris Bramley, Editor

SPECIAL EDITION



ONLY £9.99 INC FREE P&P*

FROM THE MAKERS OF BBC Sky at Night MAGAZINE

THE STORY OF VOYAGER

The twin Voyager spacecraft have been speeding through the cosmos for two-thirds of the entire Space Age. Between them they visited four planets and 48 moons, 23 of which we had no idea existed. They saw new rings, volcanoes, geysers and even aurorae. Now Voyager 1 is pushing the very limit of exploration, as it ventures into the unknown of interstellar space. In *The Story of Voyager* we explore their astounding and complex legacy, joined by some of the scientists who worked on the mission, a majestic tale that rewrote the textbooks and is still influencing NASA today.

PLUS subscribers to *BBC Sky at Night Magazine* receive FREE UK postage on this special edition!

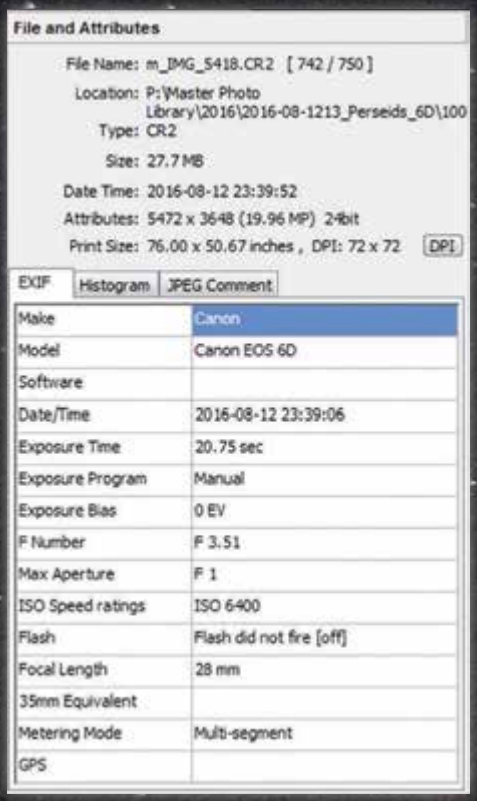
ORDER YOUR COPY TODAY

www.buysubscriptions.com/voyager

Alternatively call 03330 162138† and quote 'PRINT1'

†Calls from landlines will cost up to 9p per minute. Call charges from mobile phones will cost between 3p and 55p per minute but are included in free call packages. Lines are open 8am-6pm weekdays and 9am-1pm Saturday for orders only.

*Subscribers to *BBC Sky at Night Magazine* receive FREE UK POSTAGE on this special edition. Prices including postage are: £11.49 for all non-subscriber £12.99 for Europe and £13.49 for Rest of World. All orders subject to availability. Please allow up to 21 days for delivery.



Many digital cameras save images with an EXIF header (inset), containing all the vital info about the settings used

IMAGING FOR SCIENCE

Part 3: Meteors

Pete Lawrence explains how a handful of images can give you an idea of a meteor's speed, overall shower activity and more

PETE LAWRENCE

ABOUT THE WRITER
Pete Lawrence is an expert astronomer and astrophotographer who holds a particular interest in digital imaging

Meteors are one of the most accessible aspects of the night sky, yet on top of their undoubted splendour there's much valuable scientific analysis that amateurs can get stuck into. The core element of meteor analysis is statistical recording. Date and time stamps on images are important to identify when a meteor trail occurred.

To do this, synchronise a camera's clock with a reliable time source, like an online atomic clock. It's also recommended that you use UT. Trail timing can only be determined to the accuracy of the exposure start time plus the exposure length. A continuous record of conditions is also important as variations in factors such as sky transparency have notable effects on rates.

Most digital cameras store their settings in an EXIF (Exchangeable Image File Format) file header written into each image. However, if you're using manual lenses add a description of the lens and its settings as this information isn't normally included in the EXIF header.

Many video and high frame rate camera control programs also provide logging options to record the copious setting variants that can be applied. Finally, make a note of the centre of the sky area being photographed in RA and dec.

Hardware & Software

HARDWARE
DSLR, CCD camera, high frame rate camera, video astro camera, mid- to wide-angle lenses

SOFTWARE
Image viewer such as FastStone (www.faststone.org/FSViewerDetail.htm)
Photoshop or Gimp (www.gimp.org)
UFOCapture, UFOAnalyzer, UFOOrbit (sonotaco.com/soft/e_index.html)
MetRec (www.metrec.org)

Submit your pics for science

"Meteor imaging has seen a huge transformation in recent years," says Tracie Heywood (pictured), director of the Society for Popular Astronomy Meteor Section. "Historically, imaging was based around photographic film, which suffered the disadvantages of low capture rates, time-consuming manual processing and many 'wasted' (meteor-less) exposures. The switch to digital imaging has increased capture rates and meteor-less images can now simply be deleted and the disc space reused. The big advances have, however, involved imaging using video cameras, particularly when the cameras are automated and coordinated to monitor the same parts of the Earth's upper atmosphere.

"Software running with the cameras picks up, measures and saves video clips of moving objects that may be meteors. The camera operator can leave the system running overnight and, having had a good night's sleep, review the video clips the next morning. A few amateurs are taking the additional step of placing diffraction gratings in front of their cameras. The spectra these capture give an indication of the composition of meteors.

"There are two groups of amateurs coordinating video observations in the UK and Ireland. One is NEMETODE (www.nemetode.org). The other is UKMON (https://ukmeteornetwork.co.uk)."

www.popastro.com/meteor/index.php

PROJECT 1

Calculate a shower's activity levels

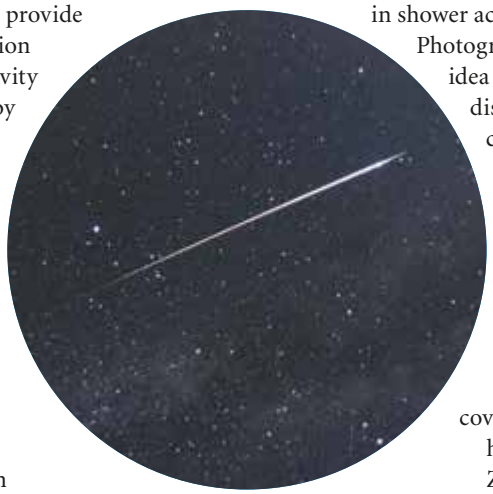
As a bonus, monitor brightness distribution, trail colours and meteor trains

Photographing a meteor shower with a digital camera can provide important information about trails and activity levels. This is done by calculating the zenithal hourly rate (ZHR), and the best way of determining that is visually.

Photographic ZHR is more complex because each camera setup is essentially unique. A calculation of camera specific photographic ZHR provides a relative indication of the change in shower activity over time.

Photographs also give an idea of brightness distribution, trail colour and train activity. A meteor train is a column of ionised gas that can sometimes be seen glowing after a bright trail has finished.

The formula covered in the six steps here is for visual ZHR and is suitable for use with visual results. It can also be applied to video results, again as a relative value unique to each setup. ▸



PETE LAWRENCE X 6

▲ Meteors can be quite colourful, a characteristic easily revealed by a camera

Shower	Peak	r
Quadrantids	3/4 Jan	2.1
Lyrids	21/22 Apr	2.1
Eta Aquariids	5/6 May	2.4
Perseids	12/13 Aug	2.2
Orionids	21/22 Oct	2.5
Leonids	17/18 Nov	2.5
Geminids	13/14 Dec	2.6
Ursids	22/23 Dec	2.0

▲ The major annual meteor showers, their peak dates and values of the population index (r), used for ZHR calculation. A value of r lower than 2.5 favours brighter meteors, with higher values favouring fainter trails.

STEP BY STEP

How to record the data you need to determine a shower's ZHR photographically

Step 1

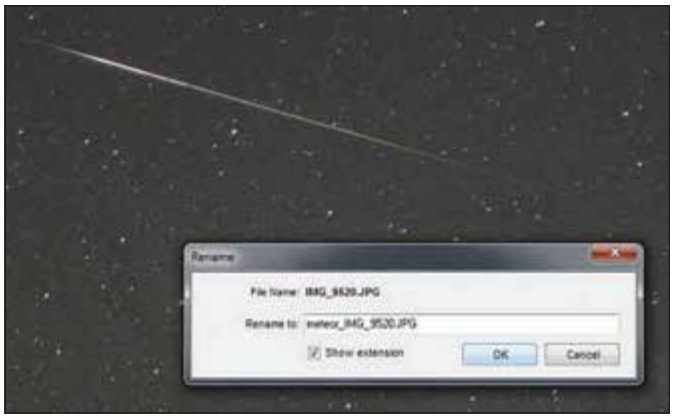
Use a fast mid- to wide-angle lens (eg 14-40mm). A 12V hairdryer or heater band can help keep it moisture free. Set to manual focus and use lowest f-number. Set the camera to manual, and ISO to half to two-thirds of maximum.

Step 2

Tracking or fixed mounts are fine. Focus at infinity. Selecting JPG over RAW reduces frame transfer times albeit with reduced quality. Choose exposures of 30-60 seconds. Up to 30 seconds, set camera to continuous shooting and lock the button down on a remote shutter release.

Step 3

For longer exposures, use a programmable release with the camera in bulb mode. Record the limiting magnitude (dimmest star visible) and radiant altitude every 15 minutes. Estimate the radiant altitude using a planetarium program or app.



Step 4

Download images and check for trails. Add a prefix of 'meteor_' onto every image in which you find one. Count how many belong to the shower. For the relative ZHR calculation, you'll also need to estimate the fraction of the sky covered by the camera.

Photographic trails - 2016-December 12/13

Time (UT)	Obs time (hrs)	lm	F	N	Rh
22:00	1.0	5.0	8	1	40
23:00	1.0	5.0	8	0	49
00:00	1.0	5.5	8	1	57
01:00	1.0	5.0	8	2	65
02:00	1.0	5.0	8	1	68
03:00	1.0	5.0	8	0	67
04:00	1.0	4.5	8	1	61
05:00	1.0	4.0	8	0	53

Step 5

To calculate relative ZHR unique to your setup, chop the session into hours. Determine the shower trail count (N), fraction of sky covered (F; for example, for one-quarter sky coverage, F would equal 4), radiant height (Rh) and the average limiting magnitude (lm).

$$ZHR_{rel} = \frac{\left(\frac{N}{T_{obs}}\right) . F . r^{(6.5-lm)}}{\sin(Rh)}$$

Step 6

Calculate your camera's relative ZHR (which isn't equivalent to a true ZHR) for the time spent observing (T obs). The population index (r) is unique for each shower and can be obtained from sources such as the International Meteor Organisation (www.imo.net).

PROJECT 2

Automated recording

Yes, you can create a setup that records videos of passing meteors while you sleep

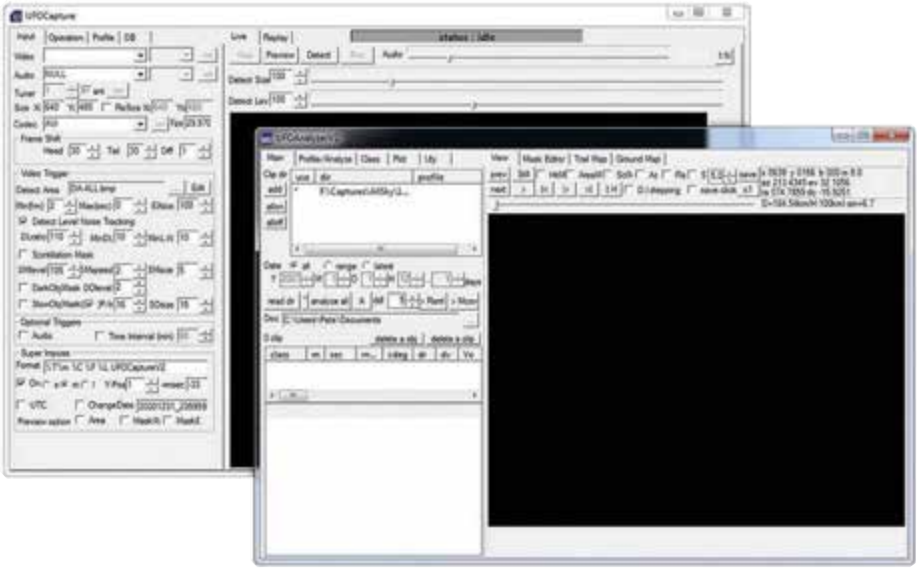
A bright fireball captured during the Perseid shower in 2016

▲ A high frame rate camera with optional DSLR camera lens adaptor

Videoing a meteor shower can provide much useful information for scientific research. Highly sensitive cameras such as the popular Watec 902H2 Ultimate CCD video camera are capable of recording meteor trails at 25 frames per second, fast enough for trail speeds to be determined.

To use such a camera you'll need a fast, wide-angle video (CCTV) lens. Cheaper lenses work well, albeit often with some image distortion, but for a serious setup it's worth investing in a decent lens.

For the camera to work continuously you should house it in a protective environment, and there are many online guides that describe how to achieve this. A CCTV housing with an internal demisting heater is an ideal choice. You'll need something like an automatic iris to protect the camera sensor from direct sunlight during the day.



▲ UFOCapture and UFOAnalyzer are two powerful programs that have been developed to streamline the capture and analysis of meteor video recordings

Capturing 720x576 video frames at 25fps produces a lot of data, especially if you're recording every night. A popular software solution is UFOCapture: it operates as a motion capture system, only recording video when an active trail passes across the frame. A cut-down and feature-limited version is available for free, and there's a more sophisticated version available as a time-limited trial. The full version costs around £130. Additional free modules can be added to the purchased version to provide further analysis of your results, including the ability to create orbital plots for the incoming meteoroid, as long as more than one station has recorded the same trail.

Many high frame rate planetary cameras can also be used for continuous recording. With these, the gain should be set relatively high to allow the exposures to be kept short, and use dark frames to reduce unwanted noise. Optional adaptors which allow DSLR lenses to be fitted are also available for some types of high frame rate camera.

Video recordings of meteor trails provide rich shower data. They can be used to calculate relative ZHRs as described in Project 1 or for further trail analysis as outlined in Project 3.

FIND OUT MORE

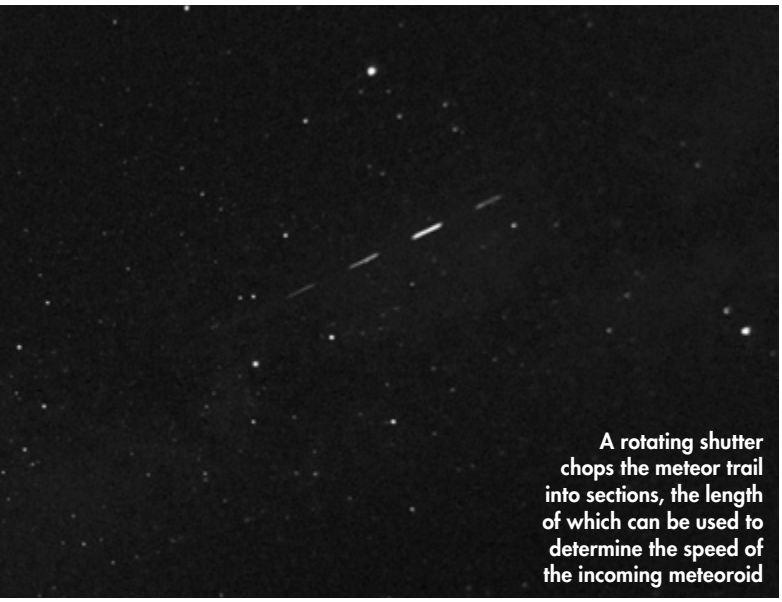
Our guide to building an all sky camera:
www.skyatnightmagazine.com/feature/how-guide/how-make-simple-all-sky-camera
Society for Popular Astronomy's Meteor Section video page:
www.popastro.com/meteor/observingmeteors/video/index.php
UKMon's guide to setting up a video meteor station:
https://ukmeteornetwork.co.uk/downloads

ALL PICTURES: PETE LAWRENCE

PROJECT 3

Taking things further – trail analysis

Studying a trail image can reveal a meteor's speed, altitude and chemical composition



A rotating shutter chops the meteor trail into sections, the length of which can be used to determine the speed of the incoming meteoroid

Two images of the same meteor from stations 3.2km apart; the parallax shift allows us to determine trail height

A surprising amount of data can be gleaned from an image of a meteor trail. For example, the trail's speed can be determined photographically by fitting a device known as a rotating shutter to the camera. This is a large disc with slots spinning at a precisely controlled rate.

The camera points though the shutter so any trail photographed appears chopped. The number of chops can be used to help determine the velocity of the meteor. Modern video cameras used for meteor work are also sensitive enough to record trails at a high enough frame rate to determine the incoming speed without the need for a rotating shutter.

It's also possible to determine the chemical make-up of a meteor by anaylsing its spectrum. The best way to get a spectrum from a trail is to fit a diffraction grating over the front of the camera, arranged so that the gratings are aligned at right angles to the trail (something which can be achieved by considering the location of the shower radiant). A grating of 600 or 830 grooves per millimetre should produce a well dispersed, bright spectrum. Plastic diffraction grating sheet is a cheap option, although for serious work more expensive glass gratings are best.

Working with other stations is a big bonus. With two images of the same trail it's possible to triangulate its position and determine the trail's height. Software like UFOAnalyzer and UFOOrbit can be used to analyse images of the same trail from multiple stations to determine the original orbit of the meteoroid.

Bright meteors often come with a glowing, ionised column of gas known as a meteor train. Photographs can help determine something called the trail brightness threshold, above which trains appear for different showers. High cadence imaging in the range 20- to 30-second exposures, on continuous repeat, often provides enough detail to trace the evolution of bright trains as they expand and become distorted by high-altitude atmospheric winds.

FIND OUT MORE

SPA guide to meteor spectroscopy:
www.popastro.com/meteor/observingmeteors/spectra/index.php
IMO guide to meteor spectroscopy:
www.imo.net/docs/03spectra.pdf

▲ A bright Quadrantid meteor trail passes through the first frame, followed by its train, which is distorting by high atmospheric winds over time

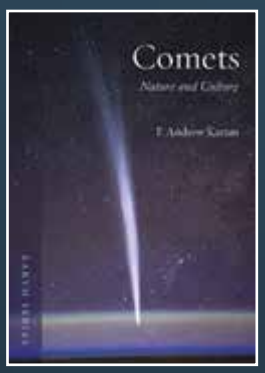
ASTRONOMER'S Gift Guide

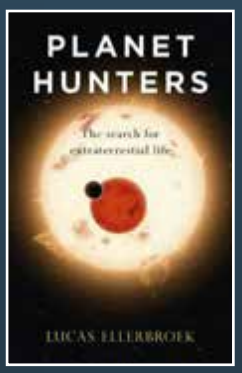
f1telescopes

f1telescopes, your friendly, helpful astronomy shop. If you are just getting started or a veteran stargazer we are here to help with a wide range of telescopes, binoculars, spotting scopes and accessories to suit all budgets. We sell Celestron, Meade, Skywatcher, Baader, Lunt, Coronado and Bresser, all at some of the most competitive prices available in the UK (Part exchange welcome). Why not give us a call on **0845 260 2622**, browse our website at **www.f1telescopes.com** or visit our shop in Sittingbourne, Kent.

Universe2go

Omegon's Universe2go offers a new approach to augmented reality, by combining the night sky with the digital world, through modern-day smartphone technology. Place your smartphone in the viewer and experience the night sky with additional information, as well as fantastic close-ups of various celestial bodies. Look to the sky to discover constellations, planets, galaxies, and more! RRP £59.90.
Contact +49 8191 94049 61 or Email: en@omegon.eu
www.universe2go.com





Reaktion Books

These brilliant new books explore our expanding knowledge of outer space, investigating historical, contemporary and future developments. Illustrated with a wide variety of beautiful images and written by expert scientists and astronomers, they will appeal to all those interested in observing and understanding the world around us. Save 20% at our website with the code **SKY20**.
Visit **www.reaktionbooks.co.uk** / **@ReaktionBooks**

Take home the most spectacular sights in our universe

Whether you're taking your first glance at the galaxy, or a seasoned stargazer, Collins has something for you.

Astronomy Photographer of the Year Collection 6

The Astronomy Photographer of the Year Collection brings together 100 awe-inspiring images of all the shortlisted and winners from the renowned annual competition. **Hardback, £25**

2018 Guide to the Night Sky

A comprehensive handbook to the planets, stars and constellations visible from the Northern Hemisphere. This practical guide is both an easy introduction to astronomy and a useful reference for seasoned stargazers. **Paperback, £6.99**

Collins

Visit **www.books.harpercollins.co.uk/astronomy**
@collinsastro collinsastronomy

nite WATCHES

Nite Watches

Nite Watches is an independent British watch brand that uses the un-rivalled and self-powered tritium illumination technology. Available exclusively online, the brilliant new ALPHA-208S T100 features sapphire crystal, screw-down crown, a ceramic bezel insert and the super-bright T100 illumination for constant visibility all night and understated style all day.
Visit **www.nitewatches.com** or call **01202 487757**

Sega Toys

SEGA TOYS

Imagine enjoying the sky full of stars while sitting on your sofa. This dream can become reality with the Homestar Original from Sega Toys. The high definition planetarium with the ultra-bright 3-watt LED and rotating movement projects the night sky throughout the year. The handy timer lets you fall asleep while gazing at the stars. Two discs included, more available. Only £99.
Visit **www.segatoys.space**

Dark Skies Jewellery

To celebrate the Gold Tier Dark Sky status, which has been awarded to 1,500 sq. km. of rural Northumberland by the International Dark Sky Association, the artist has used stunning images of planets, galaxies and nebulas to create a range of jewellery that includes earrings, cufflinks, bangles, pendants, pins and key rings. Each piece comes with a high quality photo card containing information on the reverse. This unique collection of jewellery has been greeted with delight by the star gazing community and would make an ideal gift for Christmas. To see the entire range and buy online please visit **www.darkskiesjewellery.co.uk**
or telephone **01830 540346**

Dark Skies Jewellery

SKILLS

Brush up on your astronomy prowess with our team of experts

The Guide

With
Ben Skuse

The mysteries of black holes

What have we learned in the century since they were first theorised?

Black holes are so dense that they suck up any material that passes too close; even light can't escape their clutches

NASA/JPL-CALTECH, ESO/L. CALÇADA, ISTOCK, X-RAY: NASA/UMASS/D. WANG ET AL/IR: NASA/STSCI, SWINBURNE ASTRONOMY PRODUCTIONS

A black hole is a region of space where matter has become so densely packed that its gravity will let nothing escape – including light. Time comes to a stop at its edge, and its centre may hide a point of infinitely small volume and infinite density, where all laws of physics break down.

Possessing the terrifying power to devour anything unlucky enough to pass within their grasp, it is little surprise that these cosmic chasms have become a staple of sci-fi since the term 'black hole' was coined in 1964.

Almost 50 years before this discovery, Karl Schwarzchild's solutions to Einstein's theory of general relativity had predicted how a black hole could form. In 1916, Schwarzchild predicted that if matter could be drawn tightly enough together, it could suffer a cataclysmic collapse to an infinitesimal point called a singularity, a bottomless pit in the fabric of space-time.

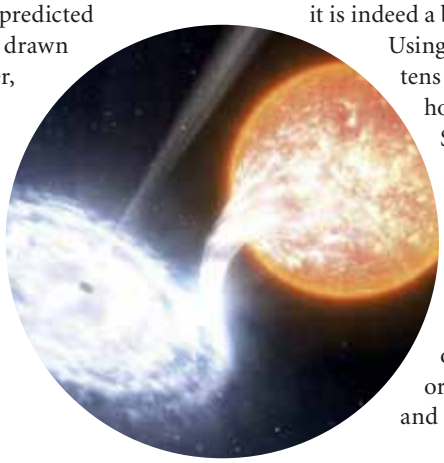
He also provided a useful distance from the centre of the black hole you would not want to go beyond, the Schwarzchild radius. This marks the boundary where the speed required to escape the gravitational pull of a black hole is equal to the speed of light. Beyond this point, matter and light are forever trapped. This is why we are not able to actually see inside a black hole.

Given that they emit nothing, not even light, how do we know that black holes even exist? The answer is that we have observed their effects on other celestial bodies and material that we can see.

The light fantastic

One of the brightest clues is the accretion disc; a flattened band of gas, dust and other debris from a star that has come close to the black hole but not quite fallen in. The particles within the accretion disc are accelerated to tremendous speeds by the black hole's gravity, in the process releasing heat, X-rays and gamma rays, which can be seen by dedicated observatories. By also measuring the orbit of the star around the hidden object, scientists can infer the latter's mass and size, and thereby confirm it is indeed a black hole.

Using this technique, tens of stellar-mass black holes have been found. Similarly, many hundreds of supermassive black holes, which sit at the heart of most galaxies, have been discovered by observing the fast orbits of stars and gas, and seeing stars being literally torn apart by the strong gravitational field.



▲ Radiation emanating from accretion discs is one way we can infer that a black hole exists

THE BLACK HOLE BESTIARY

As with many other celestial bodies, black holes can be split into classes

1 Miniature black holes

Still hypothetical, these black holes have a mass smaller than the Sun. They were first proposed by Stephen Hawking in 1971, who suggested they may have formed in the early Universe. Some experts claimed miniature black holes might appear in the collisions created by the Large Hadron Collider, but none have been detected so far.

2 Stellar-mass black holes

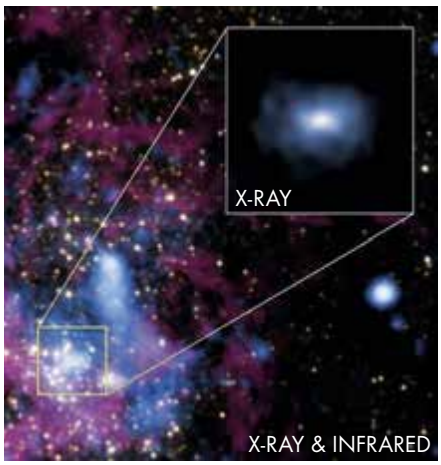
These black holes, between about 4 and 100 solar masses, are thought to be the most abundant of the four classes. Formed from the core-collapse of massive stars at the end of their lives, the nearest known one is V616 Monocerotis. It is located about 3,000 lightyears away, and is between 9-13 times the mass of the Sun.

3 Intermediate-mass black holes

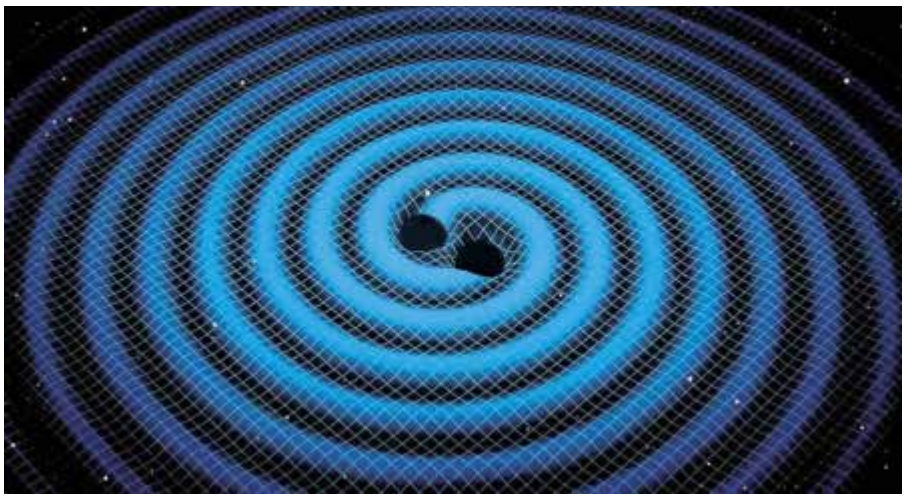
Ranging from 100 to 100,000 solar masses, only a handful of these black holes have been discovered. They have been proposed as the seeds of supermassive black holes. A Japanese team recently announced finding one close to the Milky Way's own supermassive black hole, adding fuel to the idea that these titans are formed by the merger of their smaller cousins.

4 Supermassive black holes

These can be anywhere from between 100,000 and 50 billion times the mass of the Sun. They exist at the heart of most large galaxies; even the Milky Way has one, Sgr A*. Its 1974 discoverers, Bruce Balick and Robert Brown, added an asterisk to signify the discovery was 'exciting'. Sgr A* is 4.1 million times more massive than the Sun.



▲ There's a supermassive black hole at the centre of the Milky Way – Sgr A* (inset)



▲ Gravitational waves – another Einstein prediction – have been detected from colliding black holes

Our Galaxy has a black hole at its heart too, designated Sgr A*

More recently, astronomers at the Laser Interferometer Gravitational Wave Observatory (LIGO) and the Virgo Interferometer have been using a technique called interferometry to detect gravitational waves – 'ripples' in the fabric of space-time caused by violent and energetic cosmic processes – which can be formed by the merger of two black holes. So far, five detections have been made, four involving black holes.

With black hole detections only numbering in the thousands, you might assume that these objects are rare – vanishingly so, you might say. Yet there are actually thought to be between 10 million and one billion black holes in our Milky Way alone.

Despite their abundance, there is no reason to panic: black holes will not devour the Earth nor the Universe. This is because, at a distance, their gravitational pull is no more compelling than a star of the same mass – if we were to replace the Sun with a black hole of the same mass, the planets would continue orbiting in exactly the same way, it would just be very dark and cold. So, the only way Earth could be swallowed into the abyss would be if it happened to stray across a wandering black hole's event horizon, something that is not going to happen any time soon, and likely never will.

BEN SKUSE is a mathematician turned science writer

How to...

Build an equatorial platform PART 2

Complete and motorise your baseboard so it tracks with the sky

With **Mark Parrish**

Properly motorised, the finished base will make your Dobsonian track at the sidereal rate – keeping it aligned with the stars

TOOLS AND MATERIALS

TOOLS
Jigsaw, router, hacksaw, drill and bits, plane, spanner, Allen key, screwdriver, hot glue gun, file

MATERIALS
Remainder of 18mm plywood and 30x30x2mm aluminium angle from Part 1

SUNDRIES
Modelling clay, worm, wheel, small spur gear, suitable axle (4mm rod), three M8x75 coach bolts with six M8 nuts, motor/gearbox (ours was 12V and 10rpm output speed), DC motor controller, M3 screws and nuts, M6 screw, Nylock nut and washers

FINISH
Preservative wood stain or paint

In part two of our project, we show you how to complete and motorise the Dobsonian equatorial platform. We have documented our build with downloadable photographs in this month's Bonus Content so you can replicate the parts, but because your choice of drive motor and power supply could differ according to circumstances and availability you may have to adapt the design a little to suit your kit. Our spreadsheet calculator (also in the Bonus Content) once again comes to the rescue when it comes to working out gear ratios so all you need to do is input your values and experiment with the numbers until the ratios match your needs.

Commercial motor drives for telescope mounts are available for projects like this, but they can be expensive. They use sophisticated stepper motors, which move by very small, predictable increments. Short pulses are sent to these motors by a special controller to precisely control the motion of the scope. One of these would be ideal but it is possible to build a cheaper (albeit slightly noisier) alternative. Our drive is based on a more straightforward DC motor. When the power is on, these motors turn fairly constantly, but quickly. We used a home-made gearbox along with the gearbox built into the motor, and an off-the-shelf controller to modify the output speed to suit our needs.

ALL PICTURES: MARK PARRISH

Aim for sidereal

The principle behind our motor drive is simple: the telescope's platform should rotate very slowly at the same rate as the Earth is spinning – the sidereal rate – but in the opposite direction. In 24 hours this is only slightly more than one full revolution (360°), so in one hour the platform should turn 360/24 = 15°. This is both a useful movement for observing and a sensible amount for our design to accommodate.

Since we know the radius of our north segment (from Part 1) we can work out the length of a 15° section of the circumference. After measuring the diameter of our output gear, we can work out how many times per minute it must turn to create the required movement. This is the necessary output speed for our gearbox system.

To prevent slipping, the output gear drives a toothed section of the north segment. We created this 'rack' by making a mould from modelling clay (rolling the output gear along a strip of clay to create

▲ The underside of the baseboard; here you can see the bearings, drive motor and gearbox

the profile) then filling the mould with glue from a hot glue gun. If you find this too fiddly, you can buy toothed belts with matching small gears instead. Screw some stops onto the bearing strip to prevent the platform rotating too far either way.

The DC motor you need to buy should come with a built-in gearbox with a published speed of 10rpm or less. A controller can also slow this down, so our homemade gearbox will only need to reduce the speed a little. A worm gear with a wheel (ours has 57 teeth) will do the job nicely and these can be bought online.

Grab your offcuts

Offcuts of aluminium angle saved from Part 1 are great for building the gearbox, although careful measuring and some fine tuning may be required before you get it running perfectly. Once completed, the gearbox is mounted on a pivoting arm. A rubber band pulls on this so the output gear presses against the rack and drives the platform. To reset the platform, simply disengage the pivoting arm.

The controller is connected between the motor and power supply (we used a 12V powertank for our 12V motor). You can fine-tune the speed during use by observing an object at the eyepiece and making adjustments with the knob. This may also become necessary if the battery level drops during the night.

To set up, align the baseboard north-south and get it as level as possible. Place the scope on top and switch the board on. You can fine-tune your alignment using a technique included in the Bonus Content.

Mark Parrish is a consummate craftsman. See more of his work at buttondesign.co.uk

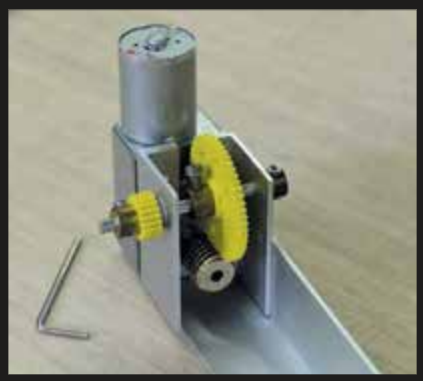
YOUR BONUS CONTENT

Download additional images and a spreadsheet calculator for this project

STEP BY STEP

STEP 1

Use the spreadsheet calculator in the Bonus Content to select appropriate gears. If your gearbox motor turns at 10rpm or slower, you will probably only need a worm and wheel. The wheel turns the output shaft, which drives the north segment.



STEP 2

Make a gearbox using offcuts of the aluminium angle from Part 1. Mark and drill holes accurately so shafts turn freely and without any play. Use M3 screws and nuts to hold it all together. A small output gear on the outside will drive the segment.

STEP 3

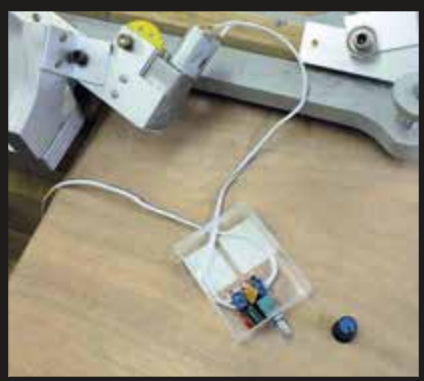
Use a strip of modelling clay and the output gear to create a profile for the rack. Put a taller strip of wood either side and fill the gap with hot glue. Once this has cooled, you can wash out the clay to reveal a plastic rack.

STEP 4

The gearbox is fixed to a short arm. The arm pivots on a piece of angled bracket, which is screwed to a raised plywood support so that the drive gear can mesh with the rack when engaged. This is a bit fiddly, so spend time refining the position.

STEP 5

Mark around the bearings and arm support to draw a suitable shape for the base. Cut this out with a jigsaw. Make three jacking screws from M8 coach bolts with captive nuts pressed into holes in the underside of the base. Paint to match the platform.



STEP 6

Assemble all the parts and check to see everything is moving freely and the gears are engaging. Solder wires to the motor terminals and connect to the controller, which should be protected in a suitable case. Connect the power.

Image PROCESSING

With **Stuart McIntyre**

INSIGHT ASTRONOMY PHOTOGRAPHER OF THE YEAR

Advice from a 2016 People & Space shortlisted entrant

IAPY masterclass:
The Man Under the Stars

How to blend land and sky, and retain the anchor of a human at the heart of it all

▲ The images that would eventually form the panorama; with the camera only moving 15° between frames, there was plenty of overlap for stitching

It is difficult to truly capture the awesomeness of our place in the Universe alongside the grandeur of the Scottish mountains in a single photograph. To capture the moment, you have to take multiple images and bring them together. Without any planning, a random stranger unknowingly added to the incredible sense of scale being striven for in this photograph. He stood on the moor, oblivious to my presence and dead centre to the mountain, Buachaille Etive Mor in the Scottish Highlands. The man is dwarfed by the mountain, and in turn the mountain is dwarfed by the Milky Way.

On location, the field of view that my camera could capture felt very limited. I wanted viewers to feel they were looking at the entirety of space, not just focusing on one part of the sky; stitching multiple photographs together was the answer. Using a Nikon 14-24mm lens on a Nikon D4S, a professional 16.2-million-pixel DSLR, gives a 114° viewing angle. Shooting in portrait orientation, I used a geared tripod head to move the camera by 15° between frames. The overlap seemed like overkill, but the extra information came in handy later when stitching the images.

Each exposure was 20 seconds at f/2.8 and an ISO of 8000. I left the automatic dark frame reduction on as I have found it produces much cleaner images than my attempts at subtracting dark frames in Photoshop. It is also highly possible that the –6°C night-time air helped the camera produce less noise. Overall it took about 14 minutes to capture the entire panorama. Any longer and star trailing might have started to cause problems.

Assembling the images without artefacts was nerve-wracking. Lightroom and Photoshop both offer stitching options with limited control, but I used PTGui (www.ptgui.com; free trial), a panoramic image stitching software for Windows and macOS. PTGui will try to merge the images for you (press **Load Images** in the initial window, then **Align Images**), but it will usually fail. After this you are invited to set 'control points'. This means you tell

The mystery hiker turned out to be another photographer, visiting from the Isle of Wight

ALL PICTURES: STUART MCINTYRE

▲ Working with two copies of the image means you can edit the foreground (left) and sky (right) separately, essential for a high dynamic range

the program which parts of the image are the same by matching up stars from different photographs. I'd recommend three to five per image.

Once I'd merged the panorama, I created a virtual copy of the photograph in Lightroom (**Photo** > **Create Virtual Copy**), so I had two: one to show the ground and the other to show the stars. Starting with the 'ground' image, I used the white balance and colour hue sliders to ensure the snow was pure white. Then I found the exposure's sweet spot so the snow looked bright and attractive, yet not glowing like in daylight.

Hunt for the hiker

At this point I was happy with how the image looked so loaded it into Photoshop. I went through the originals to find the image where the man had managed to stand still for 20 seconds (this is where having too much information helped as he appeared in seven of the frames), then cut and pasted him over the blurred image of him that appeared in the panorama.

I used Lightroom's brush tool to boost the saturation and sharpening around him to make him stand out as much as possible. I adjust the size of the brush a lot depending on the area of the photo I am working on.

Now I could move on to the 'stars' image. I always want my images to look natural and realistic so I try to be light-handed when editing. I used the white balance slider to add a slight blue tint to the sky to create the feeling of cold (because it was really, really cold) and adjusted the contrast and shadow sliders to bring out the stars.

I'm not a huge fan of emphasising the winter Milky Way but in this image, it needed to be done. Importing this photo into Photoshop I painted on a high pass sharpening filter (**Filter** > **Other** > **High Pass**). I normally select a sharpening radius of around 150. Once this is applied it will instantly make the photo look horrible.

I fixed this by setting the blending mode to Soft Light (**Layers** > **Blending Options** > **Soft Light**) and hiding the layer mask (**Layers** > **Layer Mask** > **Hide All**). I used the brush tool with 50 per cent opacity to subtly bring out the detail of the Milky Way.

At this point it was time to superimpose one photograph onto the other, achieved by clicking **Select** > **All** and then copying everything, switching to the other image and pasting. I then placed the layer that showed detail on the ground above all others, and created a layer mask over it (**Layers** > **Layer Mask** > **Hide All**). After setting the blend mode to Normal, I used a white brush (opacity 100 per cent) to paint in the details of the ground I wanted to keep. The result was the image I entered into Astronomy Photographer of the Year 2016.

STUART MCINTYRE is an astrophotographer. See more of his work at www.boundbystarlight.co.uk

Applying a high pass filter helps emphasise the Milky Way

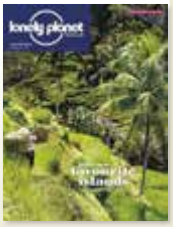
The final image of the Milky Way arcing over Buachaille Etive Mor, with the man almost lost below them

GIFT SUBSCRIPTIONS FROM ONLY £29.99

FOOD AND TRAVEL

12 ISSUES FOR £29.99
SAVE 43%

13 ISSUES FOR £29.99
SAVE 47%



12 ISSUES FOR £29.99
SAVE 40%

LIFESTYLE

13 ISSUES FOR £29.99
SAVE 48%

26 ISSUES FOR £39.99
SAVE 46%

10 ISSUES FOR £39.99
SAVE 33%

12 ISSUES FOR £39.99
SAVE 44%

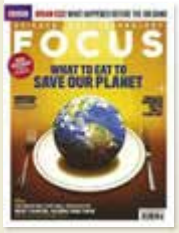
HOMES AND GARDENING

12 ISSUES FOR £39.99
SAVE 30%

13 ISSUES FOR £29.99
SAVE 46%

13 ISSUES FOR £29.99
SAVE 49%

SCIENCE AND NATURE



12 ISSUES FOR £29.99
SAVE 44%

12 ISSUES FOR £39.99
SAVE 36%

13 ISSUES FOR £29.99
SAVE 49%

13 ISSUES FOR £29.99
SAVE 46%

HISTORY

12 ISSUES FOR £29.99
SAVE 50%

12 ISSUES FOR £29.99
SAVE 50%

SPORT

13 ISSUES FOR £39.99
SAVE 44%

23 ISSUES FOR £39.99
SAVE 27%

13 ISSUES FOR £39.99
SAVE 38%

CRAFT

10 ISSUES FOR £39.99
SAVE 33%

10 ISSUES FOR £39.99
SAVE 33%

TAKE THE HASSLE OUT OF YOUR CHRISTMAS SHOPPING AND GIVE A GIFT THAT LASTS ALL YEAR

Order a magazine as a gift subscription before the 16th December and not only will you **SAVE up to 50%** on the price but we'll also send you a FREE Christmas card to personalise!

Remember ordering online is safe and secure, choose from any of these payment options

VISA MasterCard DIRECT DEBIT PayPal

SEE OUR FULL RANGE OF MAGAZINES ONLINE

ORDER NOW!

Subscribing online is quick and easy. Visit

buysubscriptions.com/christmas

mobile-friendly site · safe and secure · easy search

or call our hotline **0330 053 8660**† QUOTE CODE: X17AD

To receive your free greetings card in time for Christmas, gift orders must be received by the 16th December 2017. This offer closes on the 31st December 2017.

This offer is valid for UK delivery addresses only. All savings are calculated as a percentage of the full shop price, excluding Radio Times and Match of the Day which are calculated as a percentage of the Basic Annual Rate. For overseas rates visit www.buysubscriptions.com. All Christmas gift subscriptions will start with the first issue available in January 2018. Should the magazine change in frequency; we will honour the number of issues and not the term of the subscription. †Calls from landlines will cost up to 9p per minute. Call charges from mobile phones will cost between 3p and 55p per minute but are included in free call packages. Lines are open 8am – 8pm weekdays and 9am – 1pm Saturdays.

*Radio Times and Match of the Day are published weekly. The Basic Annual UK Subscription Rate of Radio Times is £144.78. This price is for one year and includes the Christmas double issue and a contribution towards postage. The Basic Annual UK Subscription Rate for Match of the Day is £117 for one year.

Scope DOCTOR

With **Steve Richards**

Our equipment specialist cures your optical ailments and technical maladies

Astrozap's Flexi Heat shield combines standard dew prevention with in-built heating

I have massive dew problems with my Meade ETX 125. Will this damage the telescope and how can I avoid it?

IAN JONES

The Meade ETX 125 is a Maksutov-Cassegrain telescope, the design of which includes a large and quite thick meniscus lens at the front of the telescope. Unfortunately, it is quite common for this lens to act as a 'dew magnet' in damp conditions, which can be quite a problem for observers. A standard, flexible dew shield will certainly help, and you can either buy one ready made or make your own using a camping mat cut to size, but it's likely that neither will be enough in the worst atmospheric conditions.

Dew heater tape will give you additional protection but will, of course, require a dew controller and a portable 12V power pack. Assuming that you do use a 12V power pack, you could also consider buying a 12V hair dryer, which would allow you to blow a warm draught of air over the lens surface and your eyepieces from time to time during an observing session. This can remove dew.

Another, more complete solution would be to purchase an Astrozap Flexi-Heat dew shield. This not only acts as a standard dew shield, protecting the view from local stray light, but it also has a thick film heating element built into the lower two-thirds of its length that warms the end of a telescope tube and the lens.

STEVE MARSH, PAUL WHITFIELD

► 10x50 binoculars are a great size to start out with

I'm new to astronomy and have been observing with the naked eye, managing to spot the Andromeda Galaxy. Would a pair of 20x80 binoculars on a tripod be a good next step?

KARL MCCORMICK

Spotting the Andromeda Galaxy for the first time can really ignite a desire to see more of the Universe than can be done with the naked eye, and a pair of binoculars is an excellent first step. Even simple binoculars will allow you to see many more objects in the night sky. You have suggested the purchase of a pair 20x80 binoculars, mounted on a tripod: I'd urge a little caution here and suggest that a pair of 10x50 binoculars would be more suitable for your first pair. 10x50 binoculars can be held by hand, easily transported and suitable for other observing opportunities, making them excellent value for money and ensuring that you will use them regularly. You can also put your money into better crafted binoculars to avoid problems such as miscollimation, which will pay dividends in the future. There's every likelihood that you'll still be using and enjoying them for years to come.

STEVE'S TOP TIP

What's the best way to focus on diffuse objects?

Achieving focus on diffuse objects such as nebulae can be a little tricky, imaging more so than visually, but the key in both instances is to focus on the stars in the view rather than the diffuse object itself. For observers, rack the focuser through the focus point and back again a couple of times to get a feel for the exact point at which the star is at its smallest; for imagers, use a Bahtinov mask. If necessary, move the telescope a little to find a suitable nearby star. If the stars are in focus, your diffuse object will be in focus too.

Steve Richards is a keen astro imager and an astronomy equipment expert

Email your queries to scopedoctor@skyatnightmagazine.com

SPECIAL SCIENCE-FOCUSED ASTRONOMY VOYAGE

© Øystein Lunde Ingvaldsen

HURTIGRUTEN

NORWAY'S ASTRONOMY & AURORA

See the aurora borealis and star-filled night sky of Norway the way it is meant to be seen; far from artificial ambient light and with a front-seat view on the deck of a Hurtigruten ship as she sails into the Arctic Circle along the Norwegian coast.

12-day Astronomy Voyage & Northern Lights

Including return flights from the UK

Bergen – Kirkenes – Bergen | Departs 3rd December 2018

SAVE UP TO £350PP OFF EARLY BIRD PRICES

This fascinating science-focused voyage offers a great opportunity to discover more about the Northern Lights and the cosmos. There's also a great range of exciting excursions including snowmobiling and Husky dog sledging.*

VOYAGE INCLUDES:
Lectures/presentations by one of two renowned astronomers – Dr John Mason MBE and Ian Ridpath


© Shutterbird Productions


© Shutterstock


© Ole C. Salomonsen

Your 12-day voyage itinerary

DAY 1: Embarkation, Bergen
DAY 2: Ålesund
DAY 3: Royal City of Trondheim
DAY 4: Arctic Circle and Lofoten
DAY 5: Tromsø, Gateway to the Arctic
DAY 6: Honningsvåg and the North Cape
DAY 7: Kirkenes
DAY 8: Hammerfest and Tromsø
DAY 9: Vesterålen and Lofoten Islands
DAY 10: Arctic Circle and Seven Sisters Mountains
DAY 11: Trondheim and Kristiansund
DAY 12: Bergen and disembarkation

FULL-BOARD VOYAGE INCLUDING FLIGHTS

12 DAYS FROM **£1,577pp**

PRICE INCLUDES:
✓ Return flights and transfers ✓ Onboard lectures/presentations from a renowned Astronomer
✓ Onboard Expedition Team enhancing your experience through a series of lectures and activities
✓ Choice of cabin grade and cabin number ✓ Full Board ✓ Fully refurbished ships
✓ Free Wi-Fi ✓ Complimentary tea & coffee ✓ Choice of preferred dining time
✓ Offer combinable with 5% Ambassador Discounts

NORTHERN LIGHTS PROMISE
If the Lights don't show, get another voyage FREE!**

Northumbria CRUISE CLUB

Call Northumbria Travel on 01670 829922

Visit **www.northumbriatravel.com** or email us at **info@northumbriatravel.com**
82 Front Street East, Bedlington, Northumberland NE22 5AB

Price shown is per person based on two people sharing an inside cabin including full board voyage and return flights from London and transfers. Regional flights available at a small supplement. *Available to book at extra cost. Price includes the £350 discount advertised. Prices and availability correct at time of going to press. **Receive a 6-day Classic Voyage South or 7-day Classic Voyage North FREE OF CHARGE if the aurora borealis does not occur on your 12-day voyage. Hurtigruten's full terms and conditions apply.

ABTA ABTA No. V7545

BBC Sky at Night MAGAZINE

Reviews

Bringing you the best in equipment and accessories each month, as reviewed by our team of astro experts

HOW WE RATE

Each category is given a mark out of five stars according to how well it performs. The ratings are:

★★★★★ Outstanding
★★★★★ Very good
★★★★★ Good
★★★★★ Average
★★★★★ Poor/Avoid

This month's reviews

FIRST LIGHT

90 Sky-Watcher Evostar-90 AZ Pronto and mount

94 Revolution Imager R2 CCD video astronomy camera

98 Opticron Adventurer II WP 10x42 binoculars

BOOKS

102 We rate four of the latest astronomy titles

GEAR

104 Including this light pollution filter

Find out more about how we review equipment at **www.skyatnightmagazine.com/scoring-categories**

SEE INTERACTIVE 360° MODELS OF ALL OUR FIRST LIGHT REVIEWS AT WWW.SKYATNIGHTMAGAZINE.COM

90

A straightforward scope and mount package suited to grab and go astronomy

FIRST **LIGHT**

See an interactive 360° model of this scope at **www.skyatnightmagazine.com/evostar90az**

Sky-Watcher Evostar-90 AZ Pronto telescope and mount

A complete package with everything you need to start stargazing

WORDS: PAUL MONEY

VITAL STATS

- **Price** £259
- **Aperture** 90mm (3.5 inches)
- **Focal length** 900mm (f/10)
- **Optics** Two-element, air-spaced objective lens
- **Focuser** Single speed rack and pinion
- **Mount** AZ Pronto
- **Tripod** Adjustable legs (78.5-150cm)
- **Extras** 6x30 finder, 25mm and 10mm 1.25-inch eyepieces, 90° 1.25-inch erect-image diagonal, tripod extension tube
- **Weight** 6.25kg (tube 2.4kg, mount and tripod 3.85kg)
- **Supplier** Optical Vision
- **www.**opticalvision.co.uk
- **Tel** 01359 244200

SKY SAYS...
There was no colour fringing noticeable on stars; Altair in Aquila appeared pin sharp across almost the entire view

Entry-level telescopes often get bad press but, given the chance, they can surprise in terms of what they are able to reveal in the night sky. The Sky-Watcher Evostar-90 AZ Pronto is one such instrument. It consists of an achromatic refractor and Sky-Watcher's newest altaz mount, the AZ Pronto.

The refractor has a 90mm (3.5-inch) front lens with two elements to help keep colour fringing to a minimum, although this optical arrangement is not sufficient to eliminate it completely. Its focal length is 900mm, giving it a focal ratio of f/10 – enough light grasp to provide reasonable views of a range of targets, from the denizens of the deep sky to the planets and the Moon.

An erect-image diagonal is supplied, so as a bonus you could also use the telescope for terrestrial viewing too. Two eyepieces are provided, 25mm and 10mm, which give magnifications of 36x and 90x with this scope. A 6x30 straight-through finderscope completes the optical setup, and it gives reasonable views of bright stars, allowing you to navigate the night sky and home in on deep-sky targets through star hopping.

The AZ Pronto mount and tripod system is well made and easy to use. When the locking clamps on each axis are loosened slightly, the mount can be moved manually, and there are smooth slow-motion controls for both axes to help you fine tune onto targets. The slow-motion controls can also be attached at two different points on each axis, which may prove useful if you ever wanted to replace the supplied refractor with a reflector.

The tripod has an adjustable height range of 78.5-150cm, gives enough support and is reasonably sturdy, without suffering too much from vibration. We also found the supplied tripod tube extension to be a particularly useful inclusion. When viewing targets close to the zenith a refractor's focuser can end up quite low down, but with the extension in place, you don't have to bend down quite so far.

Eagle vision

Aiming at Altair in Aquila, we examined the field of view using the 25mm eyepiece. Altair was nice and crisp at the centre and remained so for around 70 per cent of the view, beyond which some colour fringing and distortion crept in – though the view was acceptable enough.

We then took a tour of some late summer favourites, including the Dumbbell Nebula (M27 in Vulpecula), the Ring Nebula (M57 in Lyra), and globular cluster M13 in Hercules, examining them all with both supplied eyepieces. The wide field of view of the 25mm eyepiece delivered a quite small but still distinctive view of M57 and showed M13 as a hazy glow, whilst the 10mm eyepiece gave a hint of stars scattered across the globular. Turning roughly northeastwards, we homed in on the galaxy pair of ▸

LIGHTWEIGHT AND STRAIGHTFORWARD

A telescope will see a lot of use if it is easy to operate and can be set up without a lot of fuss. The Evostar-90 AZ fits the bill for both: we found it easy to assemble and, at a combined weight of 6.25kg, light enough to lift as a single unit. The mount head and tripod weigh 3.85kg together, the refractor 2.4kg. The scope attaches to the mount head via a Vixen-style mounting bar and is firmly held in place with a single knob, which can be quickly released for ease of transport. This makes it ideal as a grab and go setup to catch breaks in the clouds or take to remote observing sites to view special events or just enjoy darker skies.

FINDER & FOCUSER

The 6x30 straight-through finder is small; the view was acceptable for locating bright targets and star hopping, but a little difficult to use when locating high-up targets. The focuser is a basic rack and pinion design with a locking screw to provide additional tension.

EYEPIECES & STAR DIAGONAL

Two basic but useful eyepieces are supplied, 25mm and 10mm, providing magnifications of 36x and 90x. This is a good range for the light grasp of the Evostar-90 AZ, although a 2x Barlow lens would have been a welcome extra. The inclusion of an erect-image diagonal also allows terrestrial use.

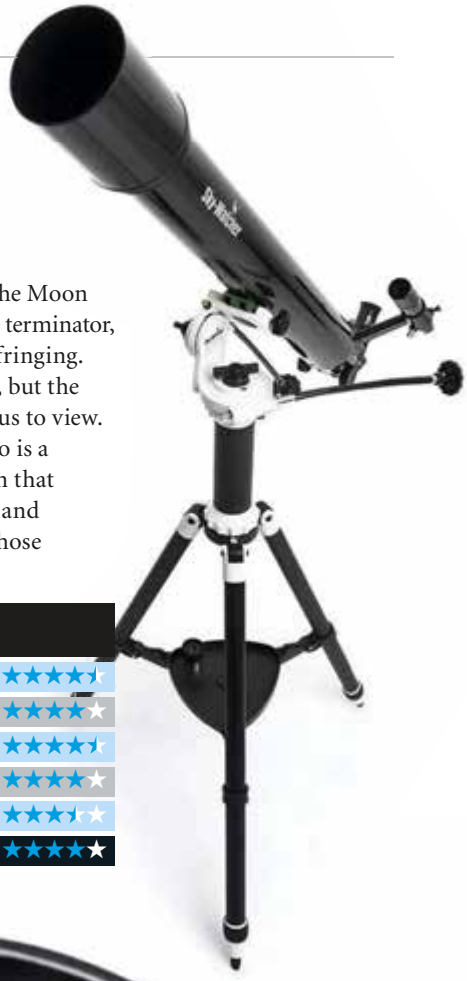
AZ PRONTO MOUNT

The new AZ Pronto mount head has slow-motion controls on the altitude and azimuth axes, and was smooth and easy to operate. It is fitted with a 45mm dovetail bar and can carry a scope weighing up to 3kg. The slow-motion controls can be attached in two positions, suiting either a refractor or reflector.

TRIPOD & EXTENSION

The tripod has telescopic aluminium legs that can be extended and clamped in any position using the integral locks, and they provide a height range of 78.5cm to 150cm. The tripod extension pillar is useful for a refractor when a target is high in the sky, making the eyepiece quite low.

FIRST LIGHT



SKY SAYS...
Now add these:
1. Sky-Watcher 2x Barlow
2. Planetary & lunar filter set
3. Red LED torch

▸ M81 and M82 in Ursa Major, and both comfortably fitted into the field of view of the 25mm eyepiece. M82 appeared as a thin sliver, M81 as a subtle oval glow.

Over in the east we examined M45, the Pleiades in Taurus, and with the 25mm eyepiece it took on the guise of a sparkling scattering of diamonds – we counted 49 of its stars with ease. We even suspected that we could see the Merope Nebula, but sky conditions were not good enough to be sure. To push the optics we turned to the wonderful double star Albireo in Cygnus, revealing the contrasting golden yellow and sky blue of their separated components. We pushed the optics further still by using our own 2x Barlow lens with the 10mm eyepiece, and were able to split triple star Iota Cassiopeiae into its three components. The Moon appeared crisp, with lots of detail along the terminator, although off axis there was some colour fringing. We also picked out Uranus and Neptune, but the brighter planets were not well placed for us to view.

The Sky-Watcher Evostar-90 AZ Pronto is a simple to assemble and easy to use system that should whet your astronomical appetite, and can also act as a grab and go system for those fleeting moments of clear sky. S

VERDICT

ASSEMBLY	★★★★½
BUILD AND DESIGN	★★★★☆
EASE OF USE	★★★★½
FEATURES	★★★★☆
OPTICS	★★★½☆
OVERALL	★★★★★

OPTICS

The scope has a 90mm, two-element, air-spaced objective lens and a focal length 900mm, giving a focal ratio of f/10. The two air-spaced elements help to reduce the effect of colour fringing on targets such as the Moon and bright stars. The dew shield also gave good protection to prevent the lens dewing up.

FIRST **LIGHT**

See an interactive 360° model of this camera at **www.skyatnightmagazine.com/revimagerr2**

Revolution Imager R2 CCD video astronomy camera

A complete kit that grants live views of the cosmos – just add a telescope

WORDS: PETER JENKINS

VITAL STATS

- **Price** £324
- **Sensor** 1/3-inch Sony ICX811 CCD
- **Resolution** 720x576 pixels (5µm square)
- **Exposure range** 1/10,000th of a second to 5.12 seconds
- **Exposure modes** Auto/Manual/Fix
- **Soft case size** 320x200x80mm
- **TFT monitor size** 7 inches
- **Extras** Battery and charger, 1.25-inch adaptor, 0.5x reducer, infrared-cut filter, umbilical cable including wired remote.
- **Supplier** Modern Astronomy
- **www.**modernastronomy.com
- **Tel** 020 8763 9953

SKY SAYS...
This is a comprehensive, inexpensive and fun way to view faint deep-sky objects

The Revolution Imager R2 is a complete camera and monitor kit that allows you examine the view through your telescope on screen and in real time. With it, you can view details that would be impossible to see with an eyepiece alone. It is often said that when looking through a telescope eyepiece you can be disappointed, that you can only faintly make out most nebulae and that what you can see is not very colourful. This camera kit makes it possible to see details in many of these nebulae, and to see them in full colour via a live view on a screen. The view on the monitor is displayed with astounding colour and clarity and for clubs, outreach or star parties this will certainly be a winner.

The Revolution Imager comes in a soft case that includes the camera, a 12V rechargeable battery plus charger, a 7-inch colour monitor with an adjustable stand and a number of accessories – a 1.25-inch nosepiece, a 0.5x focal reducer and a 1.25-inch infrared-cut filter. There are also separate remote controls for the camera and the monitor, and all the cables needed to connect everything together. This is an exceptionally comprehensive package that includes everything needed to get imaging straight out of the box.

Although all these items are included, there are several valuable accessories available that were loaned to us for the purpose of this review. These included a number of lenses that attach directly to the camera (allowing you to use the camera as a standalone device), longer connecting cables and a video capture device so you can save images directly onto a computer via a USB connection. Note that you cannot save the video that the camera records without a capture card of some kind.

To approximate the field of view of the camera's 1/3-inch Sony ICX811 sensor with your telescope, we recommend consulting our online field of view calculator (**www.skyatnightmagazine.com/astronomy-field-view-calculator**). Select your telescope and manually enter the pixel size (5µm) and the image size (720x576), then select a target from the available lists to approximate the view you will see when using the camera.

Pleasant surprises

The TFT monitor is surprisingly sharp and its colour rendition is excellent. It is worth making some adjustments to the brightness and contrast settings using the camera remote, as the default settings for deep-sky viewing are not optimal out ▸

BUILDING THE BIGGER PICTURE

The heart of the system is the analogue video camera which has a 1/3-inch Sony ICX811 CCD sensor. The resolution of this sensor is 720x576 pixels with a pixel size of 5µm. Exposure times of between 1/10,000th of a second and five seconds can be selected using the camera's remote control.

The exposure time setting can be confusing as these are designated in an unusual way: longer exposures are expressed in the menu as multiples. For example, 256x is the longest exposure and equates to 5.12 seconds. Images can be stacked 'on the fly' from up to six frames at once, which increases sensitivity and reduces noise in the resulting image. A word of caution here – if you want to use the maximum of six stacked frames with five-second exposures, then you will need to be using a mount that can accurately track your object for at least 30 seconds; you'll also need to be patient as the image builds up on the screen.

WWW.THESECRETSTUDIO.NET X 4, PETER JENKINS X 2

EXTRAS

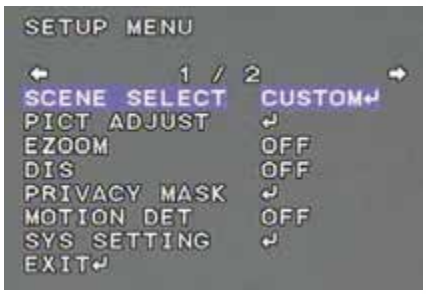
As well as the camera and monitor, the kit includes a simple instruction manual, monitor stand, 12V battery with mains charger, monitor remote control, nosepiece, 0.5x reducer, camera remote control, infrared-cut filter and all necessary cables. This is all contained in a soft padded case.

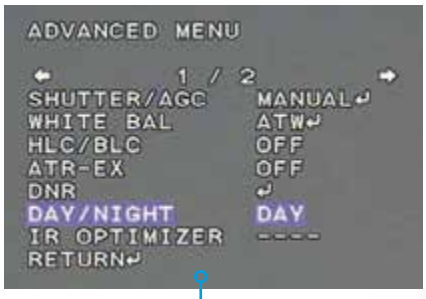
SCREEN VIEW

This is an unprocessed DSLR photograph of the view on the TFT monitor during a live viewing session of the Dumbbell Nebula. The image could be shown on a larger monitor or television as most are equipped with analogue inputs. Longer cables (an optional extra) would then be needed.

TFT MONITOR & STAND

The 7-inch TFT monitor has a standard 0.25-inch tripod screw that connects to the stand. If you have limited space to place the monitor next to your scope, a camera tripod can be used instead.





MENU

The menu system is quirky, and may have originally been designed so that this camera could be used for purposes other than astronomy. For example, exposure settings are expressed as multiples (eg, 256x), DNR is the number of frames to stack, AGC is the gain setting.

FIRST LIGHT

HAND CONTROLLER

The hand controller gives access to the on-screen menu system and is supplied with its own soft case. It connects between the camera and the monitor cable. The OK button brings up the on-screen menu and functions are selected using the arrows on the controller. Note that the down arrow is not required and is disabled.

▸ of the box. The supplied 12V battery powers both the camera and monitor, and can do so for up to five hours on a full charge. The supplied manual is sparse, but enough to get started; the manufacturer's website (**www.revolutionimager.com**) provides much more information. No software is required and, once everything is connected, the system works impeccably. Should you decide to capture images with an optional video capture device, the resulting video can be saved as an AVI file for further processing using the freeware programs such as AutoStakkert! and RegiStax.

We connected the camera to our 115mm (4.5-inch) refractor, chose the recommended settings for exposure and AGC (gain), aimed at a bright star and, using a Bahtinov mask, found focus without problems. We then slewed to M13 in Hercules and, with the same settings for exposure and gain, were treated to a fine view of this globular cluster.

Rewarding and fun

To test the camera's sensitivity we then slewed to the Dumbbell Nebula, M27 in Vulpecula, increased the exposure to the maximum, gain to 32 and the number of frames to stack to six (the maximum). We were delighted and surprised again by the view afforded, as the frames gradually built up. We subsequently captured some of the live video and processed it, with good results for such a basic system. The resolution of only 720x576 pixels is not up to modern astrophotography standards, but to be able to see such detail and colour in a nebula with such minimal equipment is rewarding and fun.

On a separate night of exceptionally poor seeing interspersed with cloud, we slewed to the Moon, shortened the exposure to 1/500 seconds, set minimum gain and single exposures. The six captured videos were processed using RegiStax and the images stitched together, resulting in a good image of the terminator. This kit represents a comprehensive, inexpensive and fun way to view faint deep-sky objects. It is also a great introduction to astro imaging, not to mention one that provides wonderful enjoyment and entertainment. S

▲ M13, the Great Globular in Hercules, stacked from 200 video frames

▲ M27, the Dumbbell Nebula in Vulpecula, stacked from 200 video frames

◂ This composite image of the lunar terminator was created from six short AVIs processed in RegiStax and stitched together using Photoshop

VERDICT

BUILD AND DESIGN	★★★★½
CONNECTIVITY	★★★★½
EASE OF USE	★★★★½
FEATURES	★★★★½
IMAGING QUALITY	★★★☆☆
OVERALL	★★★★★

SKY SAYS...
Now add these:

1. USB video capture adaptor
2. 25ft stand-off cable
3. A range of CS lenses

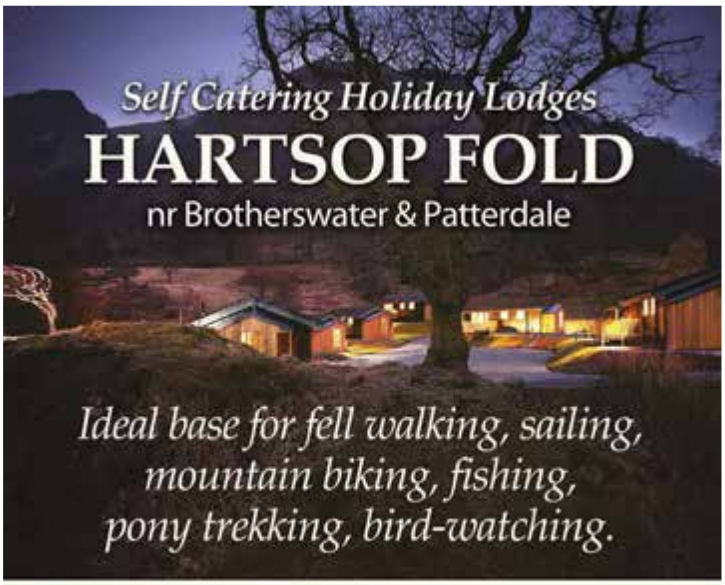
WWW.THESECRETSTUDIO.NET X 2, PETER JENKINS X 3

Triscombe Farm

Exmoor Self Catering Holiday Cottages and Farmhouse B&B

Exmoor National Park.
10 s/c cottages sleeping 2-6+cot.
Secluded valley location.
Surrounded by own farmland.
Great sky views.
Indoor heated pool.
Tennis court.
5 acres of garden.
BBQ area.

WWW.TRISCOMBEFARM.CO.UK 01643851227 / 07580145608



Hartsop Fold consists of 12 self catering holiday lodges set in one of the most idyllic & peaceful corners of the English Lake District

Hartsop Fold Lodges
Crossgate Lane, Hartsop, Patterdale,
Cumbria, CA11 0NZ
07917 784977

Free WiFi spot

LATE BREAKS AVAILABLE - see website
www.hartsop-fold.co.uk

GALLOWAY ASTRONOMY CENTRE

Discover the Night Sky in Galloway

Located near the UK's first Dark Sky Park, we can give you a personalised guided tour of the wonders of our beautiful night sky. With our large 16" Newtonian telescope the views of the planets, star clusters and galaxies are truly spectacular.

To learn more about the night sky or for help using a telescope our astronomy courses are for you.

As a Skywatcher and Celestron dealer we offer free help and advice on buying a telescope.

At the centre we also provide B&B style accommodation and evening meals.

Our Stargazer Gift Voucher is a great gift for Christmas.

Prices from only £26 pppn. Children and pets welcome.
To book contact Mike Alexander: Craiglemine Cottage, Glasserton, Wigtownshire, Scotland DG8 8NE • ☎ 01988 500594 • enquiries@gallowayastro.com

www.gallowayastro.com

SAMPSON BARTON

AA 4 STAR GUEST HOUSE

Serving award winning dinner every evening. Secluded, rural location, no street lights, pitch black nights brilliant for star gazing. Ideally situated for Exmoor and North Devon coast.

CONTACT US DIRECT
for best rates/special breaks
01769 572466
mail@sampsonbarton.co.uk
www.sampsonbarton.co.uk

www.flanesford.com | info@flanesford.com | 01600 890 506

Cairngorm Lodges are just five luxury forest lodges where guests can choose to stay in a lodge overlooking a beautiful loch or in one deep in the Scots pine forest. Enjoy the freedom and tranquillity during the day to watch the abundance of wildlife who live here and then spend your evenings marvelling at the starry night sky.

The well-equipped lodges sleep four and guests enjoy the comfort of organic fair-trade bed linen and towels as well as eco-friendly products throughout. All lodges have wood burning stoves and guests are provided with an abundance of firewood from the estates own forests. You will be met on arrival by your own dedicated host who will ensure you have everything to hand for an enjoyable break on Royal Deeside & The Cairngorms National Park. Pets most welcome.

Part of the well kept secrets of Exmoor!

Within a five minute walk of the pub!

We have two holiday apartments.

Little Hanger, converted coach house, which sleeps six and is open all year. There is a wood burner with free wood.

High Hanger, is open Easter to October, is the top floor of the main house and it has direct access to a flat roof. Ideal for lying back and gazing at the stars.

An ideal place to relax and unwind!

Hartshanger Exmoor Holidays
www.hartshanger.com
01643 862700

FIRST **LIGHT**

See an interactive 360° model of these binos at **www.skyatnightmagazine.com/adventurer2**

Opticron Adventurer II WP 10x42 binoculars

You'd be hard pressed to find a better pair of binoculars for the price

WORDS: STEPHEN TONKIN

VITAL STATS

- **Price** £99
- **Optics** Fully multicoated
- **Aperture** 42mm
- **Magnification** 10x
- **Exit pupil** 4.2mm
- **Prisms** BAK4
- **Angular field of view** 5.6°
- **Focusing** Centre focus
- **Eye relief** 15mm
- **Interpupillary distance** 56-73mm
- **Weight** 623g
- **Supplier** Opticron
- **www.**opticron.co.uk
- **Tel** 01582 726522

Binoculars that are light, compact and waterproof are ideal 'take anywhere' instruments, which is why we were so keen to try the Adventurer II WP 10x42s – an updated model in Opticron's entry-level 'Adventurer' roof-prism range.

The binoculars are supplied in a soft, lightly padded case with a belt loop, a detachable shoulder strap and a microfibre cleaning cloth. The unpadded neck strap of the binoculars themselves is a comfortable 38mm wide. When you hold the binoculars up to the light, each of the exit pupils is perfectly circular, indicating that the prisms are adequately sized. We measured the exit pupil at 4.2mm, confirming that the binoculars are not stopped down internally to mask optical aberrations; this gives the Adventurer II a greater effective aperture, and hence potentially better light-gathering ability, than some binoculars that are nominally 10×50s.

The focus mechanism has a smooth, positive feel and in use we found that stars snapped to a crisp focus. The images from each side were perfectly merged, showing that collimation was spot on. When you refocus from a near object to a distant object, you will find that there is still three quarters of a turn of the focus wheel remaining. If you are short-sighted, you will be able to use this extra focal range to observe without corrective lenses. The eye relief (the ideal distance of your eye from the binocular lenses) is specified as 15mm but, even with the Adventurer II's eye cups fully down, this was insufficient to allow the whole field of view to be visible with spectacles. This could make them unsuitable if you need spectacles to correct for astigmatism.

SKY SAYS...
They are not stopped down internally, so have potentially better light-gathering than some nominal 10×50s

Distortions be gone

There was very mild pincushion distortion noticeable at the edge of the field of view. This makes straight lines appear to bow inwards, but also counteracts an unpleasant effect called 'rolling ball', which is present if there is no distortion.

Control of false colour was very good on axis, and even a gibbous Moon showed only minimal colour fringing when the limb or terminator was near the edge of the field of view. False colour on bright stars such as mag. 0.0 Vega in Lyra was barely perceptible. There was some lens flaring when the Moon was just beyond the field of view, and when ▸

WATERPROOF AND NITROGEN-FILLED

It is unusual to find binoculars that are waterproof and nitrogen-filled at this price point. Although we don't normally attempt astronomy in the rain, humid air and dew are a regular nuisance.

They are more likely to be a problem during the long, crisp, cloudless nights that favour astronomy in the winter months, which is why waterproofing is so useful – it will keep the moisture out of your instrument, where it could cause corrosion or create the conditions for fungus or algae to grow internally on the optics.

The dry nitrogen filling is an additional line of defence. Oxygen is a reactive gas, but if binoculars are filled with nitrogen, the oxygen is expelled, and so another potential agent of corrosion is eliminated. The roof-prism style helps to maintain the integrity of the waterproofing because the focusing mechanism is internal, making it relatively simple to keep the optical tubes gas-tight. This combination of features should help to keep the internal components of your investment in good condition for many years.

FULL APERTURE OPTICS

Unlike many entry-level binoculars, the Adventurer II is not internally stopped down to mask or reduce image-degrading optical aberrations – irks such as spherical aberration, chromatic aberration and field curvature. This gives it a greater effective aperture than some binoculars that are otherwise called 10×50s.

RIGHT EYEPIECE DIOPTRE

If you are sharing your binoculars with others, you will find that different people require different right eyepiece compensation. The single projecting lug on the right eyepiece dioptre is far more useful than the more common knurled ring in that it gives you a sense of the direction of adjustment, even with gloved hands.

TWIST-UP EYE CUPS

The twist-up eye cups have a 7.5mm range of movement, with two intermediate click-stops. This makes it easy to find an optimal setting for your eyes and to return to it, by feel, in the dark. Their rubber covering feels comfortable and will not chill your eye sockets on cold nights.

FIRST **LIGHT**

SKY SAYS...
Now add these:

1. Opticron roof-prism binocular tripod L-mount

2. Horizon 8115 two-way heavy duty tripod

3. Philip's *Stargazing with Binoculars*

▸ placed centrally we saw the Moon surrounded by a crisp-edged ghost image. These phenomena were not visible with Vega. Stars looked sharp over most of the field of view, with some field curvature, astigmatism and coma affecting the edge. With the binoculars mounted, we could split Albireo in Cygnus into its two components (separated by 34 arcseconds) but only in the central half of the field. The brighter of its stars appeared yellowish, while the fainter one looked white. Colour rendition is quite good, and we found we could distinguish the colours of the three brightest stars of the Meissa Cluster (Lambda, Phi^1 and Phi^2 Orionis), even with a 60%-lit gibbous Moon only 20° away.

The brighter deep-sky objects were easily visible through these binoculars, as was Neptune. Open clusters such as IC 1805 leapt out of the surrounding Milky Way. The Dumbbell Nebula, M27 in Vulpecula, appeared as a tiny elongated cloud, easily distinguishable from stars. Large asterisms, such as the Coathanger (Collinder 399), Kemble's Cascade and Eddie's Coaster were comfortably framed in the 5.6° field.

It is difficult to see how Opticron could deliver a better pair of entry-level, roof-prism binoculars at this price: they have a robust feel, yet are lighter and more comfortable to use than equivalent Porro-prism binoculars, while the nitrogen filling and the multi-stage twist-up eye cups are usually only found on more expensive instruments. Phase coatings would have improved the crispness and the colour rendition, but at a price. This could be an ideal first instrument if you are dipping your toes into binocular astronomy: it is good enough to give you a taste of the delights of this side of astronomy, and is also suitable for terrestrial interests. S

VERDICT

BUILD AND DESIGN	★★★★½
EASE OF USE	★★★★½
FEATURES	★★★★☆
FIELD OF VIEW	★★★☆☆
OPTICS	★★★½☆
OVERALL	★★★★★

WWW.THESECRETSTUDIO.NET X 2

TRIPOD BUSH

You will be able to see fainter objects and split closer double stars if you mount your binoculars. Under a screw-out cover at the end of the hinge is a metal bush; this is threaded for a standard 0.25-inch Whitworth thread for a tripod adaptor L-bracket.

LENS COVERS

Objective lens covers are probably the most commonly lost binocular accessories: if they don't fall off, they get taken off and forgotten. These ones are tethered, so you can leave them attached when you are observing. They also fit very well and so offer very good protection against dust and moisture.

Explore the night sky over the next 12 months with *BBC Sky at Night Magazine's Yearbook 2018*. This indispensable astronomy bible contains a full year of stargazing tips, projects and how-to guides, plus amazing images and dates for all the astronomical events you can't afford to miss. Each month of the year comes complete with its own detailed star chart to point you towards the best views.

Plus – subscribers to *BBC Sky at Night Magazine* receive FREE UK delivery on this special edition.

PRE-ORDER YOUR COPY TODAY

www.buysubscriptions.com/yearbook2018

Alternatively call 03330 162138† and quote 'YEARBOOK 2018 PRINT1'

†Calls from landlines will cost up to 9p per minute. Call charges from mobile phones will cost between 3p and 55p per minute but are included in free call packages. Lines are open 8.00am - 6.00pm weekdays and 9.00am – 1.00pm Saturday for orders only. *Subscribers to *BBC Sky at Night Magazine* receive FREE UK POSTAGE on this special edition. Prices including postage are: £11.49 for all non-subscriber £12.99 for Europe and £13.49 for Rest of World. All orders subject to availability. Please allow up to 21 days for delivery. Your copy will be dispatched when available from 30 November 2017.

Books

New astronomy and space titles reviewed

RATINGS

★★★★★ Outstanding
★★★★☆ Good
★★★☆☆ Average
★★☆☆☆ Poor
★☆☆☆☆ Avoid

Beyond The Sky
You and the Universe

Dara Ó Briain
Scholastic
£12.99 ● HB

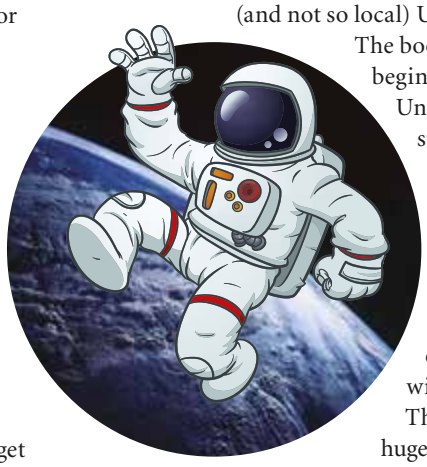
BOOK OF THE MONTH

"So you want to go into space?" asks the first page of this very readable book by Dara Ó Briain, a name familiar to viewers of *Stargazing Live*. The response – "What? Are You Mad? Why?" – explains in no uncertain terms why this would, in general, be a very bad idea, in a rather humorous and at times hilarious style that runs right through the book.

The humour is matched graphically by striking changes in font that also stretch from cover to cover – a visual style that is well aimed at this book's target age group of junior schoolchildren. For the 'traditionalists', rest assured that the readability doesn't actually suffer, and the emphasis definitely adds something.

Ó Briain writes in a comedic tone, like he speaks, and I found myself reading with the lilt of his Irish accent. The analogies and jokes are just right for the target age group, and the cartoons and diagrams are clear and nicely drawn.

After explaining why human spaceflight is so tricky, the book discusses all the other ways in which we can explore space with telescopes and robotic spacecraft. There are a couple of pages in the middle about how to become an astronaut (involving wolves and whistles from aeroplane life jackets). Despite the fact that such books take a while to write, it's bang up to date, including the prediction of Planet Nine, the discovery of TRAPPIST-1 and the recent demise of Cassini. There's a fun and exciting adventure through the history of astronomy, the Solar System, black holes, and the local (and not so local) Universe.



Don't let the illustrations fool you; this kids' book offers serious science

The book even covers the beginning and end of the Universe in a fairly straightforward (though still amusing) way, and does so without detracting from the scientific accuracy, as I would expect from someone with a physics degree.

This book will appeal hugely to younger readers, and finishes with what feels like a heartfelt plea for more astronauts, rocket scientists, stargazers, engineers, roboticists and astronomers – all nicely included in the catch-all category of "explorers".

★★★★★

CHRIS NORTH *is Odgen Science Lecturer and STFC Public Engagement Fellow at Cardiff University*

NASA, ISTOCK

TWO MINUTES WITH
Dara Ó Briain

When did you become interested in astronomy?
Growing up in Ireland, my anchor in the sky was Ursa Major, but as I got older that interest moved towards cosmology and relativity and all the yummy maths that underpinned them. It was quite refreshing to get on to *Stargazing Live* and start actually looking at things again, rather than equations.

ESA has yet to send an Irish astronaut into space. Would you like to be the first?
Depending on the scale of the mission, yes. A quick trip to the ISS would be perfect, colonising Mars less so. I don't have three years to spare at the moment; I'm about to go on tour and I have weeks to mock and robots to send to war. But I could do a week on the ISS.

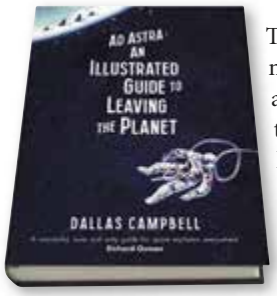
What are you hoping readers of the book will take from it?
Lots of cool facts about space and hopefully some ideas about the many different ways to explore it. Astronauts are cool, but very few of us will get to be astronauts. Lots more of us could help build a probe to orbit Saturn, say – I hear there's a gap in the market right now.

What do you think should be humanity's next big space project?
I think it's time there was somebody waving at us from the Moon again, don't you? In interactive 4K hi-def, running science lessons in real time to kids all over the world. That shouldn't be difficult to do, and imagine the face of your average eight-year-old watching that.

DARA Ó BRIAIN *is a comedian and television presenter, who co-hosts* Stargazing Live

Ad Astra
An Illustrated Guide to Leaving the Planet

Dallas Campbell
Simon and Schuster
£16.99 ● HB



There have been many books about space travel, but none like this. It is not a manual for astronauts. Instead you'll find a quirky mix of information, much of it wonderfully random.

For instance, as well as learning about the fathers of rocketry, we read of those who dreamed of spaceflight in historic times; they include Oxford scholar Dr John Wilkins who designed a chariot to fly to the Moon in the 17th century. And along with explanations of rocket propulsion comes the physics behind those space pens so often seen on sale at exhibitions.

Animals in space have their own section, from poor Laika, the stray Muscovite dog that lost her life in orbit, to a pair of Russian tortoises that beat humans to the first circumlunar trip, returning home none the worse for their adventure.

Descriptions of astronauts training in deserts and underwater are accompanied by interviews with explorers who have endured extreme conditions. The chapter on spacesuits includes a design worn only by cartoon journalist Tintin in *Destination Moon*. And we are told the detailed and gruesome truth of just what would happen to you if you stepped into space not wearing one!

Space food facts are accompanied by a recipe to make your own 'space rock' chocolates. Equally fascinating are the pages on how laws apply to activities away from Earth.

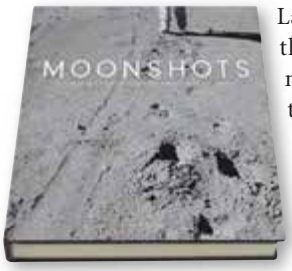
There is so much more fascinating content, all of it wittily presented by Campbell, a broadcaster who has presented many popular science and technology shows. It's great fun.

★★★★★

PAUL SUTHERLAND is a space writer and journalist

Moonshots
50 Years of NASA Space Exploration Seen Through Hasselblad Cameras

Piers Bizony
Voyageur Press
£60 ● HB



Landing men on the Moon (not to mention getting them safely home) must rank as one of humanity's greatest feats. But despite the Apollo missions' undoubted technological sucesses the promise of straightforward space transport was never delivered upon. All the more reason, then, to understand exactly how Apollo came about, what it achieved, and just what its legacies actually are.

Many other books have covered this ground. This one tells the story again, but its main strength is the inclusion of photos taken by the astronauts themselves; the author's justification is that NASA's dry and technical language has proved incapable of describing the many achievements of Apollo. The iconic photos are here, of course. But the lesser-known ones have a freshness to them that reminds us of the astronauts' accomplishments, as well as the related human cost.

In some ways this is an easy sell; these photos never fail to awe. Here, they are beautifully produced and accompanied by useful summaries of each lunar mission. The book finishes with a few pictures of arguably the most obvious legacies of Apollo: the space stations, the Space Shuttle and Hubble.

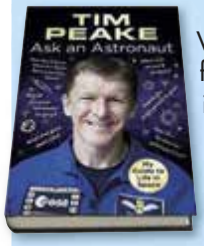
Do we really need another book about Apollo? Allegedly, many people have never heard of the Moon landings and many more refuse to believe they were real. So, yes, this is a book that is needed to inspire the next generation and remind us all what human exploration of space has achieved – and could yet achieve.

★★★★☆

PIPPA GOLDSCHMIDT *is an astronomy and science writer*

Ask An Astronaut

Tim Peake
Century
£20 ● HB



What kind of food do you eat in space? How do you weigh yourself? Astronaut Tim Peake has been asked such questions and thousands more since last year's successful ESA Principia mission to the International Space Station. And now he's compiled answers to these – and many more – in his second book, *Ask An Astronaut*.

Structured as a series of questions, we can choose to read this book chronologically or to jump in on any page. Written in a warm and relatable style, Peake reveals to us three aspects of his life as an astronaut. First, his experiences as a crew member aboard the ISS: the experiments, the daily exercises, the cleaning rota, how soft one's feet become through lack of use and how one can gaze down to Earth from the dome of the Cupola while brushing your teeth each night.

Second, the rigour, commitment and extensive training required in preparing for space manoeuvres, including his spacewalk, and launch and re-entry procedures. And, finally, the need for a solid foundation in science and engineering in all tasks as astronaut, which he capably displays in some of the more technical answers, with accompanying illustrations and graphics.

While it is not a memoir, *Ask an Astronaut* is an enjoyable read and an excellent insight into the work, life and responsibilities of these highly skilled individuals. Aimed at readers of all ages, it's the perfect gift for anyone with a passion for space and a lifelong ambition to be a part of human space exploration.

★★★★☆

NIAMH SHAW *is an engineer, lecturer and science communicator*

Gear

Elizabeth Pearson rounds up the latest astronomical accessories

1 Orion LHD 80° Ultra-Wide Eyepieces

Price £255.95 • **Supplier** Orion
http://uk.telescope.com

These eyepieces boast an ultra-wide 80° field of view, and lanthanum glass to counter colour-fringing and chromatic aberration. Available in focal lengths from 4-20mm.

2 Constellation Locket

Price £19.50 • **Supplier** Eclectic Eccentricity
www.eejewellery.com

Keep the heavens close to your heart with this locket. The pendant is decorated with a field of constellations and is suspended from a 24-inch gold plated chain.

3 AiryLab Solar Scintillation Monitor

Price £279 • **Supplier** Astrograph
0843 330 4988 • http://astrograph.net

This monitor tracks seeing conditions, only triggering your setup to take images of the Sun when conditions are at their best.

4 Constellation Socks

Price £6.99 • **Supplier** Present Indicative
01189 588586 • www.presentindicative.com

Keep your toes warm and start to learn your constellations with the aid of these cotton socks. Adult sizes 6-11 available.

5 Explore Scientific 77mm Light Pollution Filter

Price £115 • **Supplier** Harrison Telescopes
01322 403407 • www.harrisontelescopes.co.uk

Greatly improve sky contrast and reduce your image processing time with this filter, which stops unwanted light from streetlights and artificial sources reaching your sensor.

6 Meade Series 6000 0.8x Reducer/Flattener

Price £399 • **Supplier** Rother Valley Optics
01909 774521 • www.rothervalleyoptics.co.uk

This device reduces the focal length of Meade series 6000 apo refractors to increase your field of view and minimise vignetting. Connect to a scope via a 2-inch nosepiece.

WHAT I REALLY WANT TO KNOW IS...

Why is the detection of gravitational waves from a kilonova so important?

Dr Charles Kilpatrick, the first to spot light from a gravitational wave event, says it will help tell us how gold is created

INTERVIEWED BY PAUL SUTHERLAND

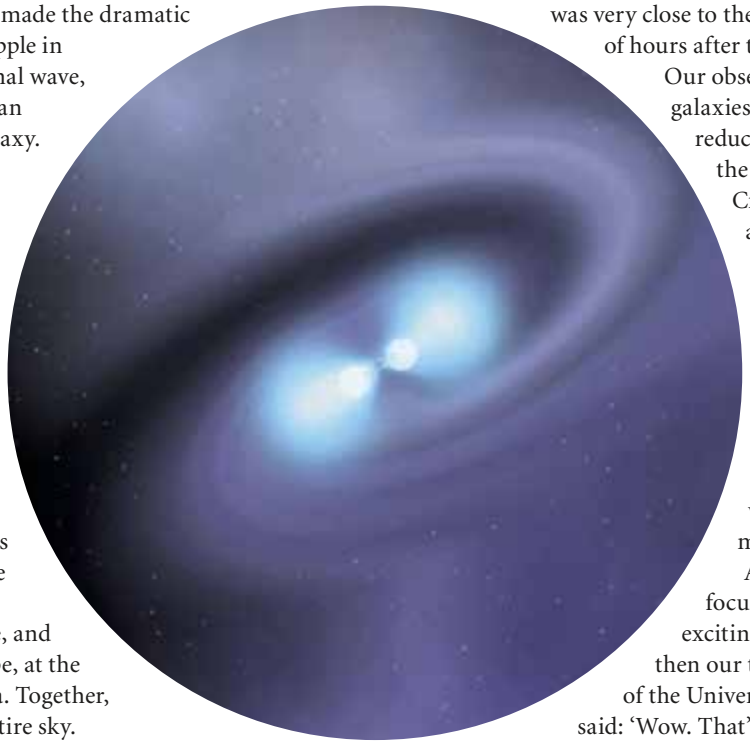
In October, astronomers made the dramatic announcement that a ripple in space-time, a gravitational wave, had been matched with an explosive event in a distant galaxy. It's the first time we've ever seen light associated with a gravitational wave event.

I was the first person to set eyes on this remarkable sight, thought to be the merging of two neutron stars in a kilonova. I had spotted it on an image of the galaxy which lies 130 million lightyears away.

I am part of a group called the One-Meter Two-Hemispheres (1M2H) Collaboration. We use two 1m telescopes. One is the Swope at Las Campanas, Chile, and the other is the Nickel telescope, at the Lick Observatory in California. Together, they give us coverage of the entire sky.

The gravitational wave event, labelled SSS17a, was detected on August 17 by two observatories, LIGO in the US and Virgo in Italy. Almost simultaneously, two space telescopes, Fermi and Integral, detected a gamma-ray burst, dubbed GRB 170817A. Along with other astronomers we received a rapid email alert, and quickly swung into action to try to locate it.

LIGO and Virgo pointed us to a region of sky where the wave's source was thought to be. It was a very large area of around 30 square degrees, equivalent to more than 100 full moons, but we had a strategy for searching for it which involved identifying likely galaxies. We would then photograph those galaxies and look for something new that was not there in archived images.



This gravitational event was born of a kilonova created by two colliding neutron stars

On high alert

As soon as we got the alert, one of my colleagues put together a list of galaxies at the sort of distance at which the event was thought to have occurred. We then sent that list of targets to our observer on the Swope telescope in Chile. We knew we had to be quick because the patch of sky we needed to check was very close to the Sun and would set a couple of hours after twilight.

Our observer went through the galaxies one by one, and I began reducing the data in my office at the University of California Santa Cruz as each image was recorded and sent to me. And in the ninth image, when I looked at a galaxy known as NGC 4993, which is in Hydra, I saw a source that I did not see in the archived picture. Our image of the galaxy was taken almost exactly 11 hours after LIGO detected the gravitational wave, and it took me just 20 minutes to find the visible source.

At the time, I was really focused on the process, and it was exciting to be wrapped up in it. But then our team leader Ryan Foley, also of the University of California Santa Cruz, said: 'Wow. That's it. That's the source'. And it very slowly dawned on me what a big deal this was. We had entered a new era in astronomy where we can simultaneously detect gravitational waves and electromagnetic emission from one event.

The SSS17a event has been called 'multi-messenger astronomy' because it was detected by telescopes observing right across the spectrum, from gamma-ray and X-ray telescopes in space, through ultraviolet, optical and the infrared, to radio wavelengths.

It is important to study because it tells us a lot about where heavy elements in the Universe come from. Neutron stars are incredibly dense. Just a teaspoon of material from one would weigh a billion tonnes on Earth. It is thought that when two neutron stars begin to collide, they throw off neutrons, which form the building blocks of really heavy elements such as gold, platinum, lead and uranium. I've heard it suggested that gold several hundred times the mass of the Earth was produced by this one merger.

As an optical astronomer, I'm really interested in how often neutron star mergers happen. Hopefully, when we've seen a few more of them, we will be able to figure out the rate at which they occur.

ABOUT CHARLES KILPATRICK

Dr Charles Kilpatrick of the Astronomy and Astrophysics Department at the University of California Santa Cruz has a special interest in the detection of supernovae and follow-up observations across all wavelengths

Telescope House

Telescope Specialists Since 1785

Web: www.telescopehouse.com
Email: sales@telescopehouse.com
Tel: 01342 837098

Sign Up

To Our Mailing List

EXPLORE SCIENTIFIC

G11 £3392

Telescope House bring you two revolutionary mounts: the observatory class Explore Scientific Losmandy G11 & the ultraportable Exos 2 PMC8 wireless German Equatorial systems

Explore Scientifc Losmandy G11 PMC8 Wireless EQ Mount

Both feature class-leading drive systems, the brand new Open Goto wireless control and autoguiding

Exos 2 £839

Explore Scientifc Exos 2 PMC8 Wireless EQ Mount

NEW DOBS!

6-inch £270

5-inch £175

Introducing the new Bresser Messier 5 and 6 inch Dobsonians Both come with two eyepieces, fully de-mounteable tubes with mounting rings, are prime focus astrophotography capable

BRESSER

The Explore Scientific Achromatic Doublet Refractors

AR 102mm f/6.5 £492
AR 127mm f/6.5 £560
AR 152mm f/6.5 £679

EXPLORE SCIENTIFIC

Explore Triplet Apo Refractors

127mm Deluxe FCD100 - £1862
127mm Essential Version £1267

102mm FCD100 Deluxe - £1267
102mm Essential Version- £807

80m Deluxe FCD100 Apo - £848
80mm Essential Apo £535

ZWO

ZWO Cameras at Telescope House

NEW! ZWO ASI1600 APS-C Sensor Cameras From £713

ZWO ASI071MC Cool APS-C One Shot Colour Camera - an ideal DSLR Replacement - £1498

Bresser Messier 8-inch Dobsonian £390

Dobsonians are the best value visual telescopes available - visit our Showroom to see a large range of these telescopes

Bresser 10" Dobsonian - £509

WiFi Camera

Bresser MikrOkular Full HD USB Eyepiece £50

Bresser WiFi Camera - See site for details!

Altair Astro GP CAM2 & GPCAM2 IMX224 Colour & Mono Planetary, Lunar & Solar Cameras
Colour IMX224 - £189
Mono AR0130 - £190

Revelation ASTRO

Revelation Observer's Eyepiece Kit - £124

25x100s £240

EXPLORE SCIENTIFIC

New!

92° 12mm & 17mm 92 Degree Explore Scientific Eyepieces £373

68° Degree Explore Scientific eyepieces from £110

82° Degree Explore Scientific eyepieces from £118

100° Degree Explore Scientific eyepieces from £254

62° Degree Explore Scientific Long Eye Relief Eyepieces From £76

Meade ETX90 Observer Edition With Hard Case, & Full Height Tripod Now £485
Meade ETX25 Observer Edition £699

MEADE

Telescope House are TeleVue Star Dealers. We always have a full range of their Plossl, Panoptic, Delite Delos & Ethos eyepieces on display & ready to test at our Starborough showroom

TeleVue Plossls Eyepieces from £91

TeleVue Delite Eyepieces £246

HOT DEAL

Lunt LS50 - From £1126

Excellent pressure-tuned portable Solar Scope

NEW! Explore Scientific Solarix Solar Film Filter £17

IMPORTANT NOTICE:

After nearly a decade in our Starborough Farm HQ, Telescope House are moving to our new location, just up the road in Edenbridge.

Our new address is:

Bresser UK Ltd
Unit 22 Warsop Trading Estate
Hever Road Edenbridge
Kent TN8 5LD

Lunt LS60 - From £1789

Excellent Value 100% Safe Solar Film. Ideal for DIY!

Lunt LS80/B1800 - £5276

Lunt LS00/B1200 - £6167

THE SOUTHERN HEMISPHERE IN DECEMBER

With Glenn Dawes

WHEN TO USE THIS CHART

1 DEC AT 00:00 UT
15 DEC AT 23:00 UT
31 DEC AT 22:00 UT

The chart accurately matches the sky on the dates and times shown. The sky is different at other times as stars crossing it set four minutes earlier each night. We've drawn the chart for latitude –35° south.

DECEMBER HIGHLIGHTS

The Geminids is one of the stronger and more consistent meteor showers, active from 4-17 December with a peak of around 24 hours on the 14th. Peak rates have historically reached as high as 120 per hour. Although best seen from the northern hemisphere, the shower has delivered great displays Down Under. The prospects for 2017 are reasonable, with the Moon not rising until 02:00 EST. The radiant is near mag. +1.9 Castor (Alpha (α) Geminorum) and crosses the meridian around 02:00 EST too.

STARS AND CONSTELLATIONS

The Orion Nebula (M42) appears as a fuzzy star near the Hunter's Belt. It's 1,500 lightyears away and appears to be 1° in diameter, but actually spans 35 lightyears. In Dorado there's a similar emission nebula, the Tarantula. Its angular size is only half that of M42, but it's larger at 1,800 lightyears across and farther away at 160,000 lightyears. If it was at M42's distance, the nebula would cover more than 50° of sky, three times the height of the constellation of Orion.

THE PLANETS

Saturn and Mercury are low in the twilight at the start of the month, but vanish after the first week. Only Neptune and Uranus remain: they set around 00:00 EST and 02:00 EST mid month respectively. Mars erupts into the pre-dawn sky around 02:30 EST, followed by brilliant (mag. –1.7) Jupiter about 30 minutes later. The crescent Moon is in conjunction with Mars on 14th and Jupiter on the 15th. Mercury returns quickly to the morning sky, rising around the start of twilight by month end.

DEEP-SKY OBJECTS

Aries is a faint constellation left of Taurus in the northern evening sky. Find mag. +2.6 Sheratan (Beta (β) Arietis) and look 1.6° south to locate brilliant double star Gamma Arietis (RA 1h 53.5m, dec. +19° 17'). A small scope reveals two mag. +4.5 white stars separated by 7.4 arcseconds.

Look 5.3° southwest and you will reach face-on spiral galaxy M74 in Pisces (RA 1h 36.7m, dec. +15° 47'; pictured). At mag +9.1, it is a great object to image but challenging to see through all but the largest amateur telescopes. Visually it reveals a bright, compact core, with an almost star-like nucleus, surrounded by a faint halo around 8 arcminutes in diameter. Often compared to an unresolved globular, averted vision reveals hints of the two prominent spiral arms, showing as bright and dark patches.

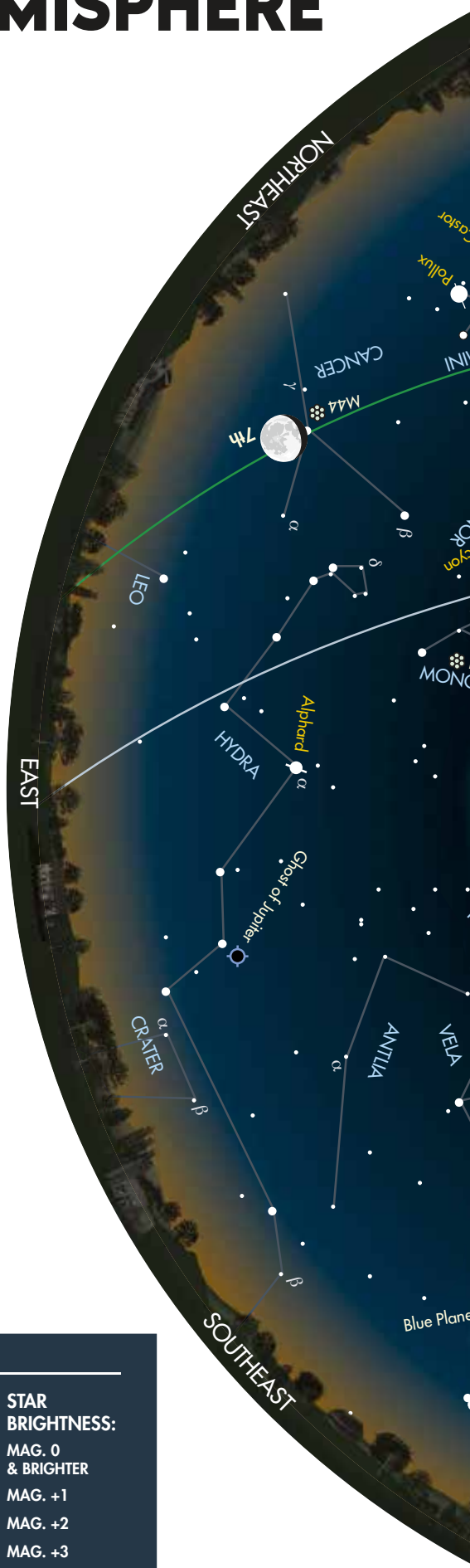
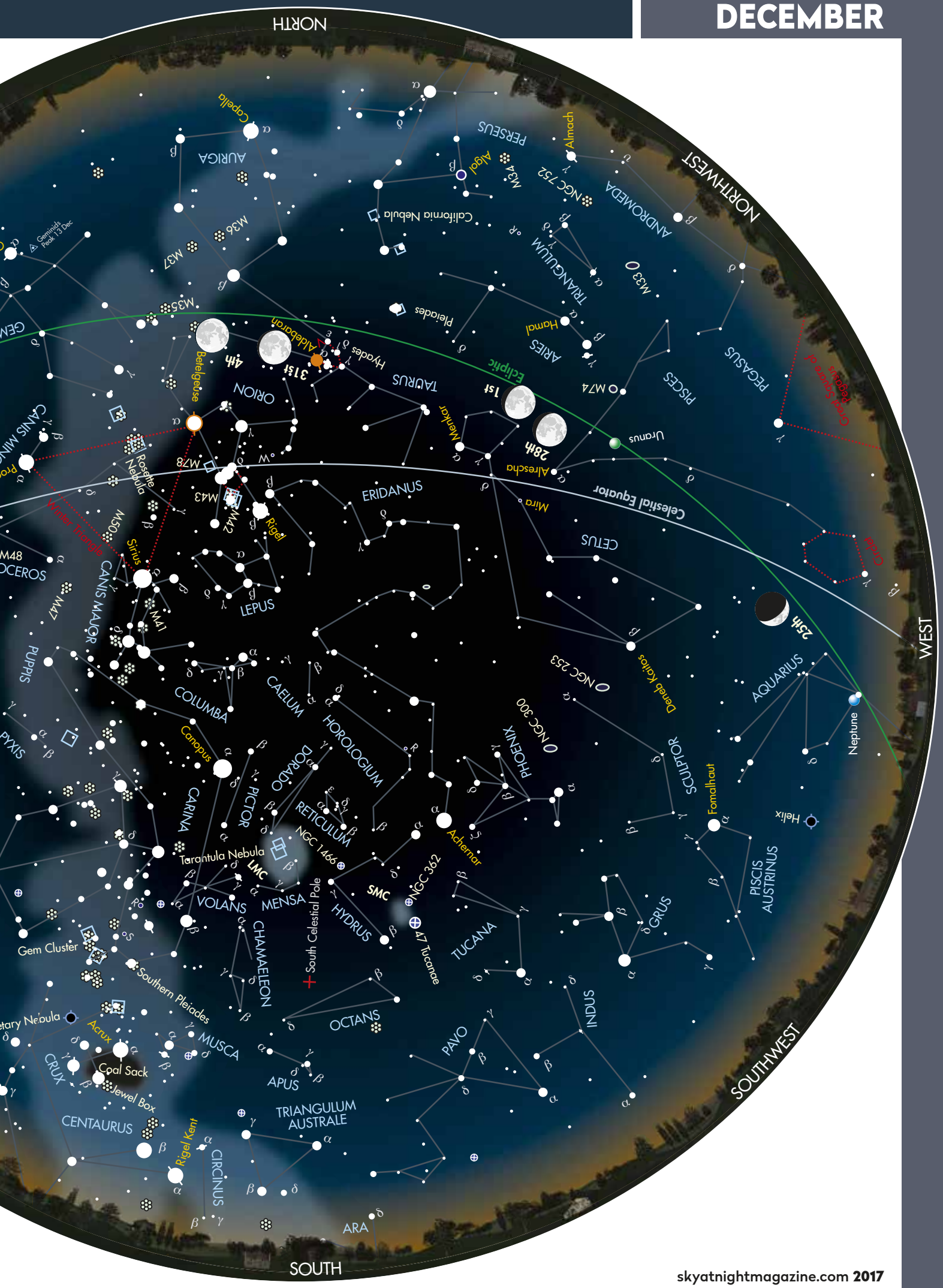


CHART KEY

- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- COMET TRACK
- ASTEROID TRACK
- METEOR RADIANT
- QUASAR
- PLANET

STAR BRIGHTNESS:
- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER

CHART: PETE LAWRENCE, IMAGE: MICHAEL BREITE/ STEFAN HEUTZ/ WOLFGANG RIES/CCDGUIDE.COM


NORTH
NORTHWEST
WEST
SOUTHWEST
SOUTH
Capella
AURIGA
PERSEUS
Algol
Almach
M34
NGC 752
ANDROMEDA
California Nebula
Geminids Peak 13 Dec
M36
M37
M35
TRIANGULUM
M33
Pleiades
Hamal
ARIES
Aldebaran
Hyades
Ecliptic
TAURUS
Betelgeuse
ORION
M74
PISCES
PEGASUS
Great Square of Pegasus
Uranus
Rosette Nebula
M78
M43
M42
Rigel
Alrescha
Mira
Celestial Equator
ERIDANUS
Winter Triangle
Sirius
M50
CETUS
Deneb Kaitos
Canopus
LEPUS
CANIS MAJOR
M41
M47
M48
COLUMBA
CAELUM
HOROLOGIUM
NGC 253
NGC 300
PHOENIX
AQUARIUS
Neptune
PUPPIS
PYXIS
CARINA
PICTOR
DORADO
RETICULUM
Achernar
SCULPTOR
Fomalhaut
Helix
Tarantula Nebula
LMC
NGC 1466
SMC
NGC 362
VOLANS
MENSA
HYDRUS
TUCANA
PISCIS AUSTRINUS
GRUS
Gem Cluster
South Celestial Pole
47 Tucanae
CHAMAELEON
Southern Pleiades
INDUS
OCTANS
Acrux
MUSCA
PAVO
Coal Sack
CRUX
APUS
Jewel Box
TRIANGULUM AUSTRALE
CENTAURUS
Rigil Kent
CIRCINUS
ARA

Sky-Watcher®

Performance, Precision and Value

Sky-Watcher is a First-Class telescope brand offering an incredible range of high-quality astronomical telescopes and accessories, catering for users of all age groups and abilities, from the novice right up to the serious advanced astronomer. Sky-Watcher astronomical telescopes perfectly integrate modern optical technology with precision mechanical engineering, resulting in designs of suberb functionality, versatility and uncompromising levels of performance.

EXPLORER-130 & EXPLORER-130M 130mm (5.1") F/900 NEWTONIAN REFLECTOR TELESCOPES

- Magnifications (with optics supplied): x36, x72, x90, x180 • Highest Practical Power (Potential): x260 • Diameter of Primary Mirror: 130mm
- Telescope Focal Length: 900mm (f/6.92) • Eyepieces Supplied (1.25"): 10mm & 25mm • x2 Barlow Lens • 30% more Light Gathering than 114mm
- R.A. Motor Drive With Multi-Speed Handset (Explorer-130M only) • Red Dot Finder • EQ2 Equatorial Mount • Aluminium Tripod with Accessory Tray

Sky at Night GROUP TEST WINNER

Explorer-130 Model

EXPLORER-130
(Without R.A. Motor Drive)
Prod.Code 10922

SRP £189

EXPLORER-130M
(With R.A. Motor Drive)
Prod.Code 10713

SRP £229

Explorer-130M Model illustrated

"Every class of object we viewed could be seen clearly… Taking everything into account, this telescope made observing the night sky enjoyable… great views coupled with ease of use."
BBC Sky at Night Magazine

PARABOLIC REFLECTORS – PREMIUM FEATURES

Both the SKYHAWK-1145P & EXPLORER-130P models below offer excellent all-round performance on The Moon, Planets & Deep Sky Objects. They feature premium quality Parabolic Primary Mirrors to eliminate spherical aberrations, producing even sharper, higher-contrast images which are full of detail. A "Paraboloidal" mirror is ground to a complex shape which brings all incoming light rays to a perfect focus, on axis. In addition they feature 0.5mm Ultra-Thin secondary mirror supports, to reduce diffraction spikes and light loss.

SKYHAWK-1145P 114mm (4.5") F/500 PARABOLIC NEWTONIAN REFLECTOR TELESCOPE

- Magnifications (with optics supplied): x20, x40, x50, x100
- Highest Practical Power (Potential): x228
- Diameter of Primary Mirror: 114mm
- Telescope Focal Length: 500mm (f/5)
- Eyepieces Supplied (1.25"): 10mm & 25mm
- x2 Barlow Lens • Parabolic Primary Mirror
- 0.5mm Ultra-Thin Secondary Mirror Supports
- Red Dot Finder
- EQ1 Equatorial Mount
- Aluminium Tripod with Accessory Tray
- 125% more Light Gathering than 76mm

Sky at Night GROUP TEST WINNER

Prod.Code 10709

SRP £159

"The optics were so good... Captures star clusters and brighter nebulae beautifully... The planet (Saturn) was jaw-droppingly beautiful, with a host of fine detail visible... The review instrument certainly delivered in every important respect."
BBC Sky at Night Magazine

EXPLORER-130P 130mm (5.1") F/650 PARABOLIC NEWTONIAN REFLECTOR TELESCOPE

- Magnifications (with optics supplied): x26 & x65
- Highest Practical Power (Potential): x260
- Diameter of Primary Mirror: 130mm
- Telescope Focal Length: 650mm (f/5)
- Eyepieces Supplied (1.25"): 10mm & 25mm
- Parabolic Primary Mirror
- 0.5mm Ultra-Thin Secondary Mirror Supports
- Red Dot Finder • EQ2 Equatorial Mount
- Aluminium Tripod with Accessory Tray
- 30% more Light Gathering than 114mm

Astronomy HOT Product

Prod.Code 10712

SRP £229

"I was most impressed by the views revealed by the 'scope during tests… Despite a phase of nearly 96 percent, the waxing gibbous Moon revealed a seemingly inexhaustible amount of fine detail... Highly recommended!"
Astronomy Now Magazine

76 page Full Colour Catalogue

COMPREHENSIVE COLOUR CATALOGUE with Full Details of our EXTENSIVE PRODUCT RANGE as well as Helpful Information & Advice

Order Your FREE Copy Today

FAX: 01359 244255
EMAIL: info@opticalvision.co.uk

Sir Patrick Moore Endorsed Sky-Watcher Telescopes

"I have used a great number of telescopes; some are good, some mediocre and some bad. To me the Sky-Watcher range of instruments are very good indeed, & suited to amateurs of all kinds - and they are not priced out of the market! Excellent value. Use them and enjoy them."
Sir Patrick Moore CBE FRS (1923-2012)

Our Products are Available from Dealers throughout the UK OVL **Please contact us, or Check our Website for your Nearest Stockist**

OPTICAL VISION LTD
UNIT 3, WOOLPIT BUSINESS PARK
WOOLPIT, BURY ST. EDMUNDS
SUFFOLK IP30 9UP

OPTICAL VISION LIMITED

www.opticalvision.co.uk
www.barrandstroud.com

Importers and Distributors of Sky-Watcher Astronomical Telescopes, Helios, Acuter, Barr and Stroud Binoculars & Spotting Scopes and 'Zenith' Microscopes.